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EC Regulation 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SANITARY SURVEY REPORT

Portsmouth Harbour

December 2013

Food Standards Agency

Cover photo: Portsmouth Harbour at low tide

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Statement of use

This report provides a sanitary survey relevant to bivalve mollusc beds within Portsmouth 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).

Revision history

Version	Details	Prepared by	Approved by	Approval date
01	Draft for internal review	Alastair Cook	Simon Kershaw	12/09/2013
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Consultation

Consultee	Date of consultation	Date of response
Portsmouth Port Health	20/09/2013	13/11/2013
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Natural England	20/09/2013	14/10/2013

Dissemination

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

Recommended Bibliographic Reference

Cefas, 2013. Sanitary survey of Portsmouth 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 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 anticipated that the sanitary survey may serve to help to target future water quality improvements and improve analysis of their effects on shellfish hygiene. Improved monitoring should lead to improved detection of pollution events and identification of the likely sources of pollution. Remedial action may then be possible either through funding of improvements in point sources of contamination or as a result of changes in land management practices.

This report documents the information relevant to undertake a sanitary survey for Native oysters (*Ostrea edulis*) Manila clams (*Tapes philippinarum*), native clams (*Tapes decussatus*), American hard clams (*Mercenaria mercenaria*) and cockles (*Cerastoderma edule*) within Portsmouth Harbour. The area was prioritised for survey in 2013-14 by a shellfish hygiene risk ranking exercise of existing classified areas.

1.2. Area description

The survey area is a large natural harbour situated on the south coast between Southampton Water and Langstone Harbour, its location is shown in Figure 1.1. A long narrow mouth connects it to the eastern Solent. The estuary covers an area of approximately 16 km², of which approximately 61% is intertidal (Futurecoast, 2002). It contains naturally occurring stocks of native oysters, clams and cockles which support commercial dredge fisheries.

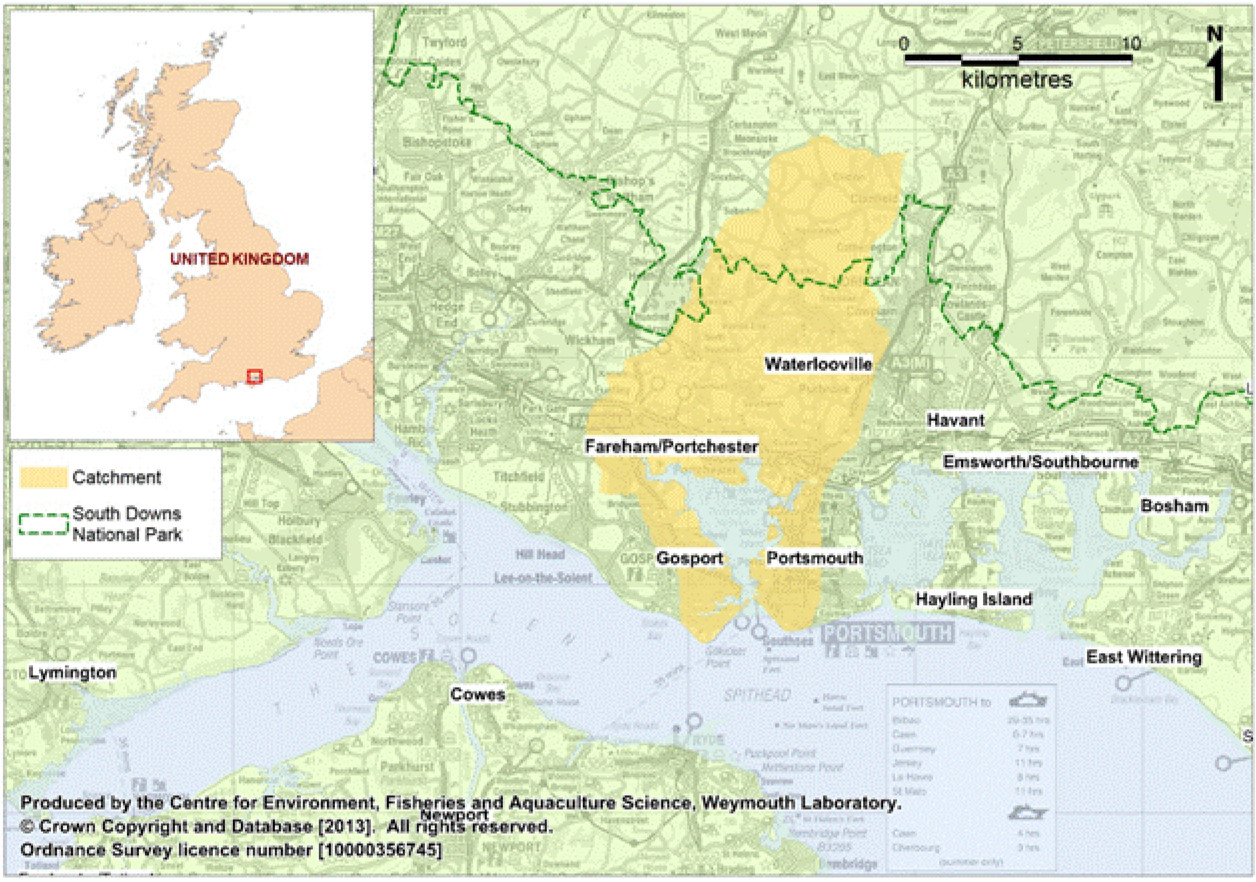


Figure 1.1: Location of Portsmouth Harbour

The upper estuary of Portsmouth Harbour is designated as a Special Protection Area (SPA), a Ramsar site and a Special Site of Scientific Interest (SSSI) as it has been recognised both nationally and internationally as an important site for overwintering birds and for its estuarine habitats. These habitats include large areas of intertidal mudflats, saltmarsh, seagrass beds and sand and shingle beds.

Boating traffic within Portsmouth Harbour is particularly heavy as it hosts a naval base, a commercial port, ferry terminals and a commercial fishing fleet. There are also several watersports clubs and marinas within the harbour.

1.3. Catchment

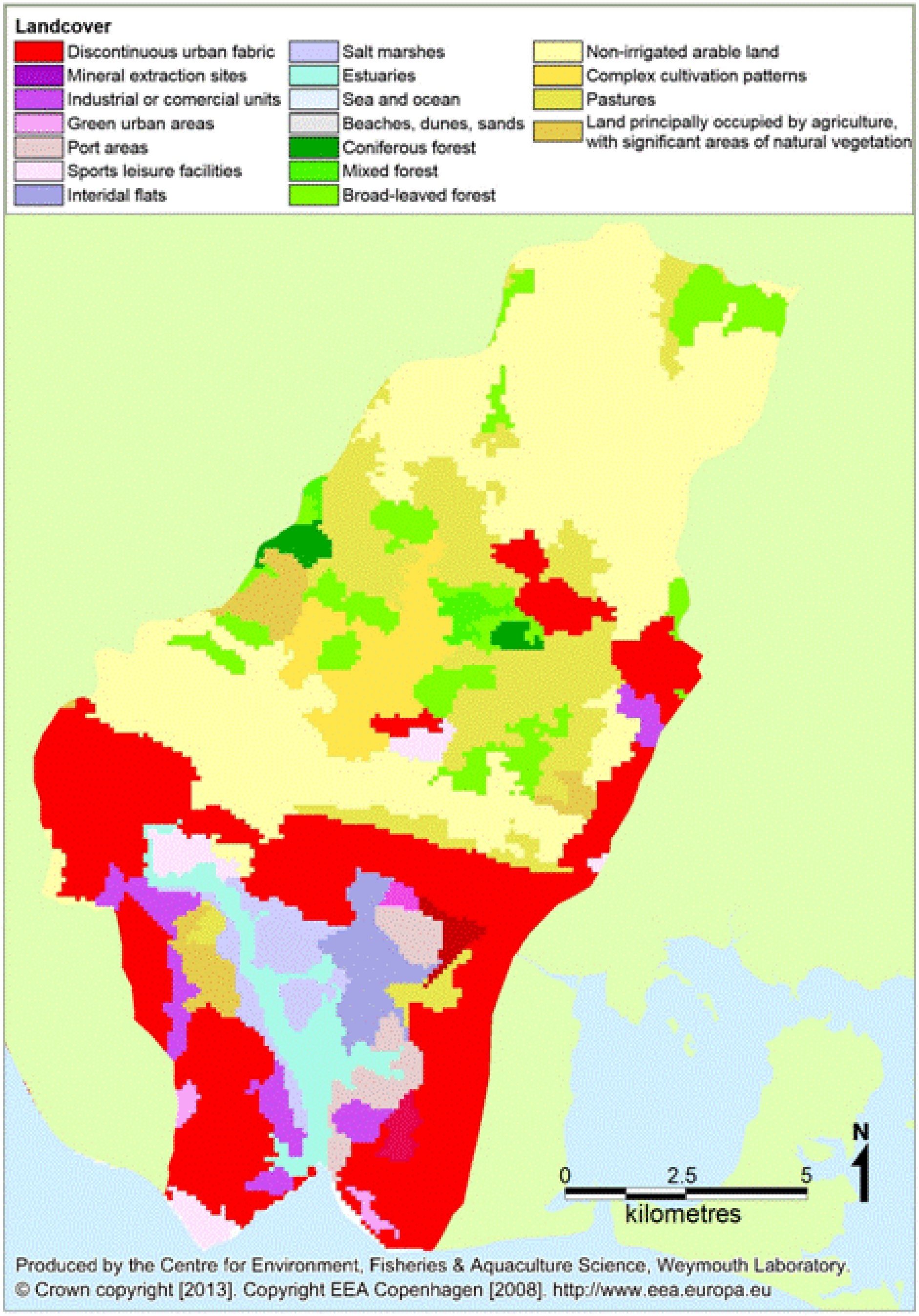


Figure 1.2: Landcover in Portsmouth Harbour catchment area

Figure 1.2 illustrates landcover within Portsmouth Harbour catchment area, which covers approximately 159 km². There is a marked division between the land use in the upper and lower catchments. The lower catchment is highly urbanised containing the towns of Portsmouth, Hayling Island, Portchester and the commercial port areas. The upper catchment is rural in character, consisting of a mixture of arable farmland, woodland, pasture and agriculture. Its' uppermost reaches lie within the South Downs National Park.

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 increase up to 100 fold.

The upper reaches of the Portsmouth Harbour catchment are underlain with chalk, and here water travels through aquifers rather than through surface watercourses. The lower reaches are predominantly underlain with clay (Portsmouth Water, 2013) so groundwaters re-emerge and travel via surface watercourses.

2. Recommendations

2.1. Native oysters

Native oysters are widely distributed throughout the harbour but confined to the subtidal channels. There is no shellfish dredging in the outer harbour due to shipping channels and no dredging in the upper reaches of the Fareham channel for conservation reasons. It is proposed that the following two native oyster classification zones are established.

West Harbour. The main contaminating influence to this zone is the River Wallington. Urban runoff from a large number of small surface water outfalls is also likely to be a significant influence. There are also six intermittent discharges direct to the zone, of which five are monitored and spilled for less than 0.5% of the time in recent years. There are also numerous intermittent discharges to the Fareham channel, upstream of the zone. Boat moorings are present throughout the subtidal channels. It is recommended that the RMP is located at the upper boundary of this zone, in the main channel just off Frater to best capture microbiological contamination from the River Wallington and other sources discharging upstream of the fishery.

East Harbour. There are no major point sources of contamination within this zone. Urban runoff from a large number of small surface water outfalls is likely to be a major influence. There are two intermittent discharges to the north shore at Portchester, but neither of these has spilled at all in recent history. There are also three intermittent discharges at Stamshaw all of which spilled for less than 0.1% of the time in recent years. The main concentration of moorings is in the Paulsgrove area. It is possible that some contamination is delivered to the area from the Ports Creek. An RMP at the confluence of the Portchester and Tipner Lakes should adequately capture contamination from all these sources, although it is quite possible that peak levels of microbiological contamination occur in the shallower intertidal areas around the Paulsgrove/Portchester area and up towards the motorway bridge.

The following sampling criteria should apply to all native oyster RMPs:

- The species sampled should be market size (70mm) native oysters.
- The sampling method should be dredge.
- A tolerance of 100 m applies to allow repeated sampling via dredge.
- A minimum of 10 samples per year are required to maintain classification.
- If two months are not sampled, these should be the first two months of the closed season (currently March and April)

2.2. Clams and cockles

Both clams and cockles are widely distributed throughout the intertidal areas of the inner harbour. The target species in the clam fishery is Manila clams, with some limited bycatch of native clams and hard clams. The main remaining clam concentrations are at the higher elevations in the north east harbour. The locations of the main cockle concentrations are uncertain. It is proposed that the following three classification zones are established for all clam species and cockles.

West Harbour. The main microbiological contaminating influence to this zone is the River Wallington. Urban runoff from a large number of small surface water outfalls is also likely to be a significant influence. There are also six intermittent discharges direct to the zone, of which five are monitored and spilled for less than 0.5% of the time in recent years. There are also numerous intermittent discharges to the Fareham channel, upstream of the zone. Boat moorings are present throughout the subtidal channels. It is recommended that the RMP is located at the upper boundary of this zone, on the intertidal just off Frater to best capture microbiological contamination from the River Wallington and other sources discharging upstream of the fishery. Should a formal ban on harvesting be implemented in the seagrass areas identified by the IFCA, these areas should be removed from the classified zone.

Paulsgrove and Portchester. There are no major point sources of microbiological contamination within this zone. Urban runoff from a large number of small surface water outfalls is likely to be a major influence. There are two intermittent discharges to the north shore at Portchester, but neither of these has spilled at all in recent history. There are also three intermittent discharges at Stamshaw all of which spilled for less than 0.1% of the time in recent years. The main concentration of moorings is in the Paulsgrove area. There will be less dilution potential in the shallower, more confined areas. It is therefore recommended that the RMP is located on the intertidal area by the north shore at Paulsgrove.

Tipner. Again, there are no major point sources of microbiological contamination within this zone. Urban runoff from a large number of small surface water outfalls is likely to be a major influence. A small watercourse drains to the eastern end of this zone, by the motorway roundabout bridge. There are no intermittent sewage discharges to this zone, although there are three to the north east corner of Langstone Harbour. Two of these are monitored, and one spilled for 4% of the time and the other for <0.5% of the time in recent years. Exchange of water between the harbours is mainly into Portsmouth Harbour, so these may be of occasional influence. There will be less dilution potential in the shallower, more confined area up towards the motorway roundabout bridge. It is therefore recommended that the RMP be located on the intertidal area just west of the motorway roundabout bridge.

The following sampling criteria should apply to all clam/cockle RMPs:

- Either Manila clams (*Tapes* spp) or cockles can be sampled and used to classify Manila clams, native clams and cockles. This classification may also be applied to hard clams to save separate sampling of this (minor) species, although it is known that they generally accumulate *E. coli* to lower levels.
- The species sampled should be of a market size (35mm for Manila clams, 23.8mm for cockles).
- 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.
- The LA should contact the FSA regarding practical sampling options, to ensure that sample collection method meets all the appropriate requirements.

3. Sampling Plan

3.1. General Information

Location Reference

Production Area	Portsmouth Harbour
Cefas Main Site Reference	M020
Ordnance survey 1:25,000 map	Explorer 119
Nautical Chart	Imray 2200.5

Shellfishery

Species	Culture (wild/farmed)	Seasonality of harvest
Native oysters (*Ostrea edulis*)	wild	November to February only
Manila clams (*Tapes philippinarum*)	wild	n/a
Native clams (*Tapes decussatus*)	wild	n/a
American hard clams (*Mercenaria mercenaria*)	wild	n/a
Cockles (*Cerastoderma edule*)	wild	May to January only

Local Enforcement Authority

Name and address	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

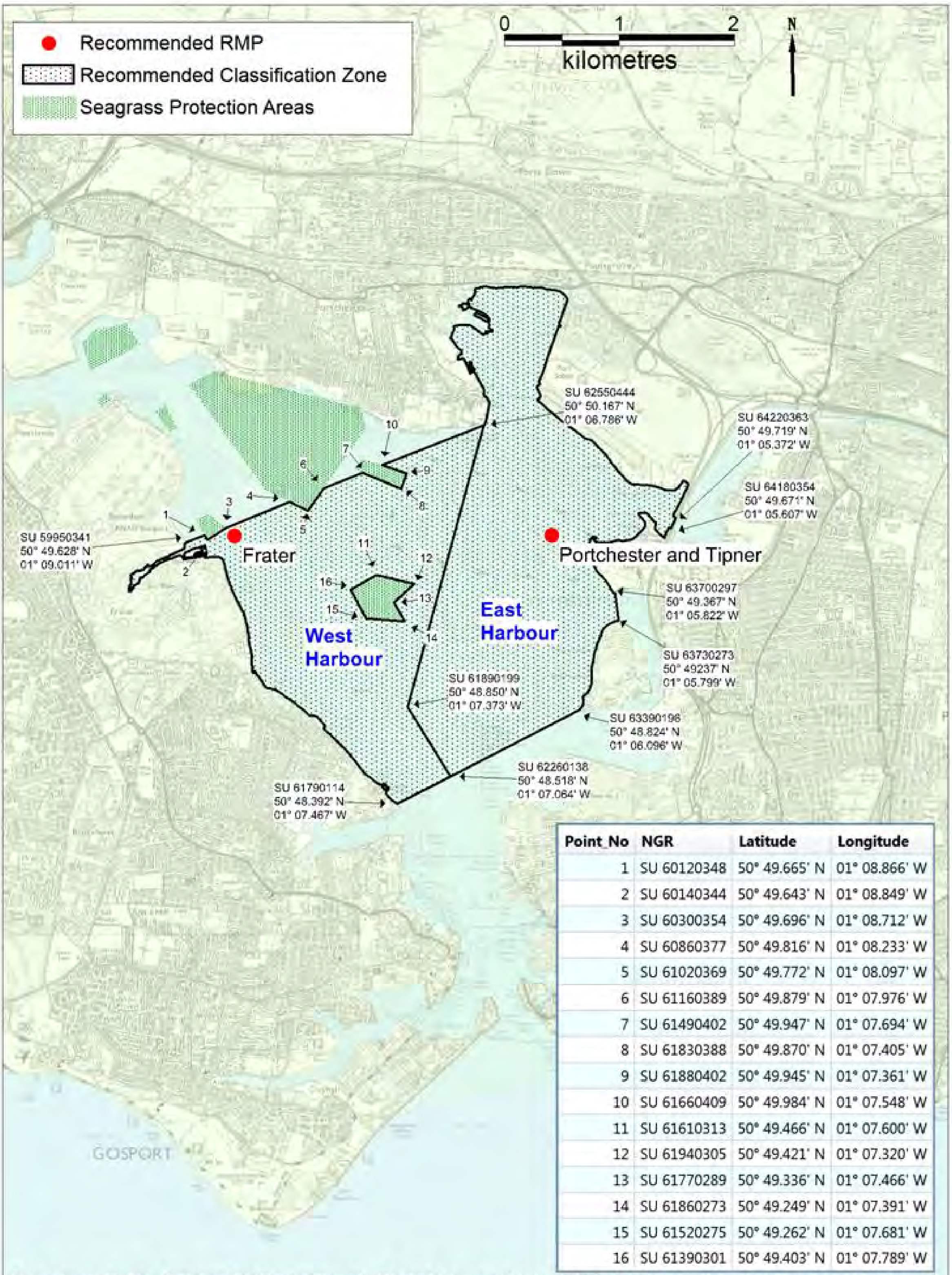
3.2. Requirement for Review

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 if any significant changes in sources of microbiological contamination or the fishery are identified.

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

Classification zone	RMP	RMP name	NGR	Latitude & Longitude (WGS84)	Species	Growing method	Harvesting technique	Sampling method	Tolerance	Frequency	Comments
West Harbour†	TBA*	Frater	SU 6038 0348	50º 49.66'N 01º 08.64'W	Native oyster	Wild	Dredge	Dredge	100m	Monthly	Not necessary to sample the first two months of the closed season (currently March and April) assuming all other 10 months are successfully sampled.
East Harbour	TBA*	Portchester &Tipner	SU 6314 0349	50º 49.65'N 01º 06.29'W	Native oyster	Wild	Dredge	Dredge	100m	Monthly	
West Harbour†	TBA*	Frater	SU 6029 0342	50º 49.63'N 01º 08.72'W	Cockles or *Tapes* spp.	Wild	Dredge	Dredge/Hand	100m	Monthly	Cockles or *Tapes* spp. can be sampled to represent cockles, *Tapes* spp. and hard clams
Paulsgrove and Portchester	TBA*	Paulsgrove	SU 6285 0544	50º 50.70'N 01º 06.52'W	Cockles or *Tapes* spp.	Wild	Dredge	Dredge/Hand	100m	Monthly	
Tipner	TBA*	Motorway Roundabout	SU 6504 0457	50º 50.22'N 01º 04.66'W	Cockles or *Tapes* spp.	Wild	Dredge	Dredge/Hand	100m	Monthly	

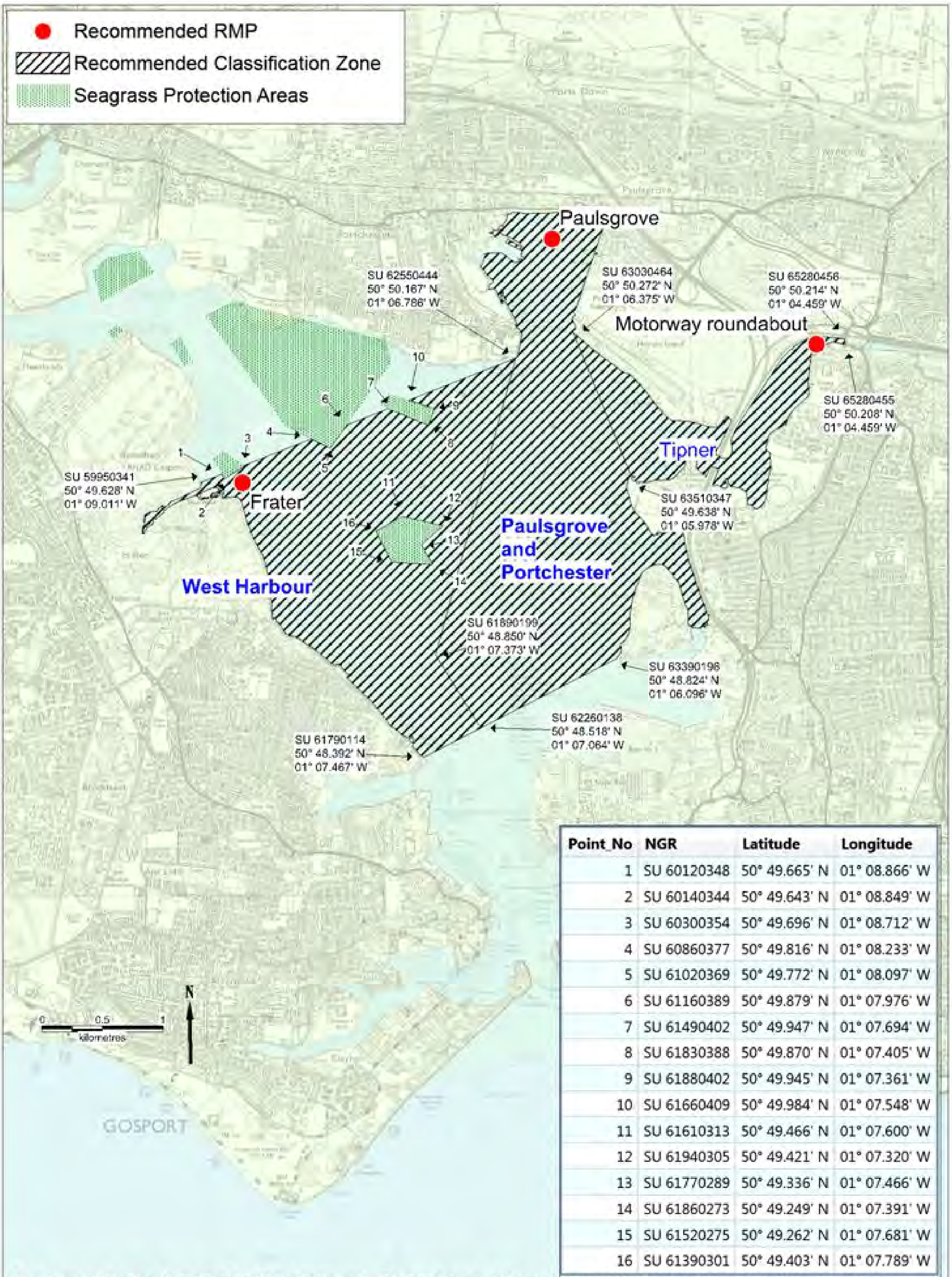
†Seagrass protection areas implemented under IFCA byelaw should be excluded from this zone.
**RMP codes will be generated once the report has been agreed and finalised.*



Point_No	NGR	Latitude	Longitude
1	SU 60120348	50° 49.665' N	01° 08.866' W
2	SU 60140344	50° 49.643' N	01° 08.849' W
3	SU 60300354	50° 49.696' N	01° 08.712' W
4	SU 60860377	50° 49.816' N	01° 08.233' W
5	SU 61020369	50° 49.772' N	01° 08.097' W
6	SU 61160389	50° 49.879' N	01° 07.976' W
7	SU 61490402	50° 49.947' N	01° 07.694' W
8	SU 61830388	50° 49.870' N	01° 07.405' W
9	SU 61880402	50° 49.945' N	01° 07.361' W
10	SU 61660409	50° 49.984' N	01° 07.548' W
11	SU 61610313	50° 49.466' N	01° 07.600' W
12	SU 61940305	50° 49.421' N	01° 07.320' W
13	SU 61770289	50° 49.336' N	01° 07.466' W
14	SU 61860273	50° 49.249' N	01° 07.391' W
15	SU 61520275	50° 49.262' N	01° 07.681' W
16	SU 61390301	50° 49.403' N	01° 07.789' W

Produced by the Centre for Environment, Fisheries and Aquaculture Science, Weymouth Laboratory.

Figure 3.1: Recommended zoning and monitoring arrangements (native oysters)



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15	SU 61520275	50° 49.262' N	01° 07.681' W
16	SU 61390301	50° 49.403' N	01° 07.789' W

Produced by the Centre for Environment, Fisheries and Aquaculture Science, Weymouth Laboratory.

Figure 3.2: Recommended zoning and monitoring arrangements (cockles and clams)

4. Shellfisheries

4.1. Species, location and extent

Portsmouth Harbour supports dredge fisheries for native oysters and mixed clam species. There is also some limited cockle harvesting.

The native oyster dredge fishery is supported by a self sustaining natural population of this species (Figure 4.1), which are taken from the main subtidal channels using dredges. Populations of this species in Portsmouth Harbour and the wider Solent area have declined significantly in recent years due to recruitment failures[1], the causes of which are uncertain (Vause, 2010). The fishery continues nevertheless.

Manila clams (*Tapes philippinarum*), American hard clams (*Mercenaria mercenaria*) and native clams (*Tapes decussatus*) are all present throughout the intertidal areas of the inner Harbour. They are exploited commercially via dredge. 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. Currently, the main focus of the clam fishery is on higher elevations in the north eastern part of the harbour where the highest concentrations of stocks remain, although dredging may occur anywhere in the inner harbour.

There is also a limited cockle fishery within the harbour. Firm information on the location and extent of these stocks is unavailable, although they are thought to be widespread throughout the intertidal areas of the inner harbour. Two fishing vessels have expressed an interest in having the fishery classified so they can continue to exploit it (Southern IFCA, pers comm.).

[1] 'Recruitment failure' - where a population is not able to produce viable off-spring or juvenile organisms do not survive to be added to a population. as a consequence of physical or biological factors.

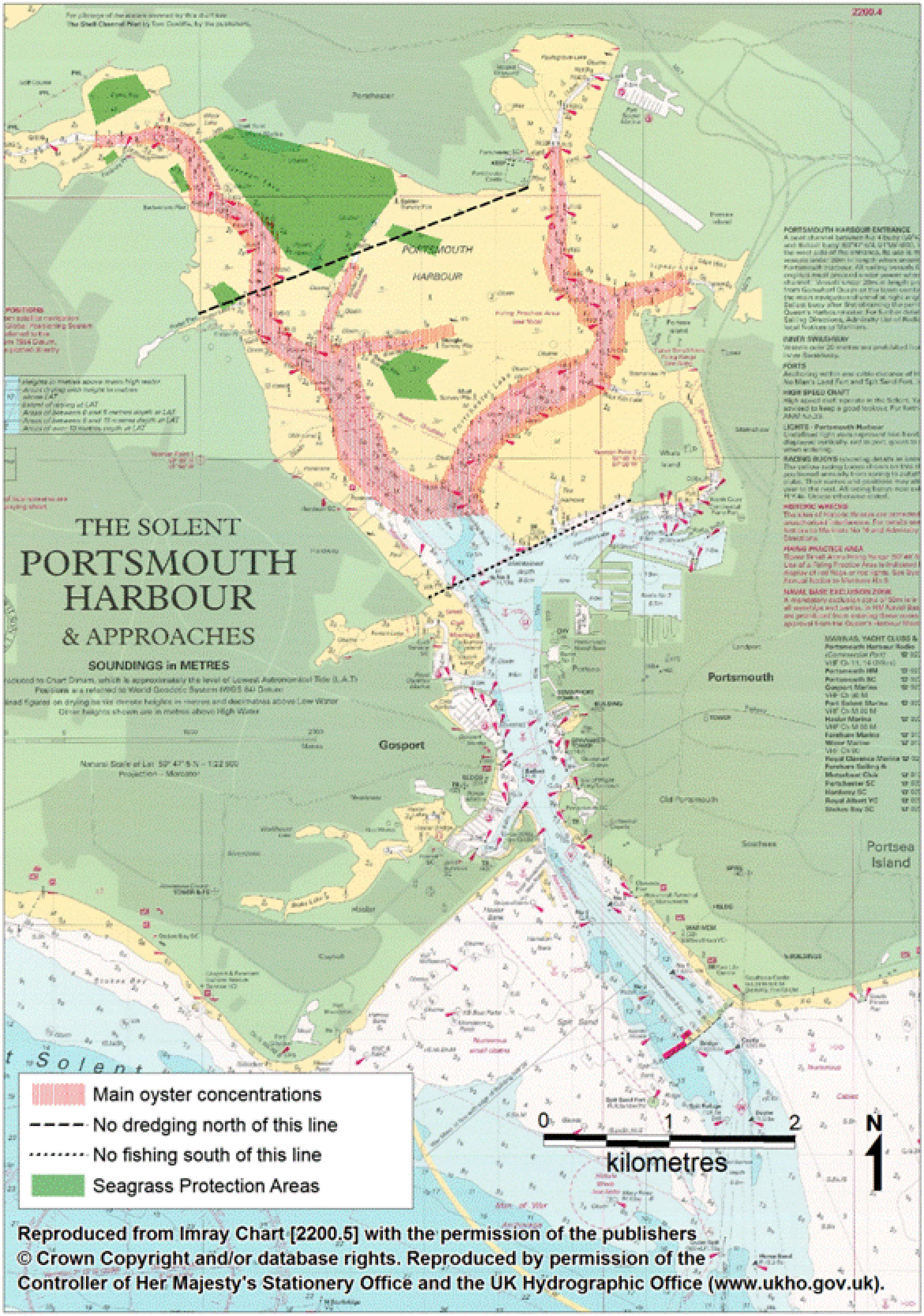


Figure 4.1: Oyster distribution and seagrass areas

4.2. Growing Methods and Harvesting Techniques

All stocks of oysters, clams and cockles are wild. The commercial harvesting technique for all is via dredges of varying configurations. It is possible that some hand gathering of clams and cockles also occurs on a commercial basis.

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 typically highest in the first week of November when the season opens. 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 in recent years and although the fishery continues, as a consequence catches have fallen. The IFCA are considering whether to further reduce the length of the oyster season for 2013/4. Should the decline continue it is possible that the fishery may become unviable or be stopped for conservation reasons in the future.

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 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. The catch per unit effort has declined significantly in recent years, from around 750kg/vessel/day three years ago, down to around 180kg/vessel/day currently. The number of vessels has also dropped significantly during this time from up to a dozen boats to much lower levels. The areas targeted have also changed, and now most effort is directed at higher elevations in the north eastern harbour, which until now have not been fished (Southern IFCA, pers comm.). This all suggests a major decline in clam stocks over the last few years.

There is a closed season for cockles from February to April inclusive, and a minimum landing size of 23.8mm applies.

The ‘Protection of the Portsmouth Harbour Special Protection Area byelaw 2012’ prohibits the use of shellfish dredges in the upper reaches of the western arm of the harbour, north of a line drawn from Portchester Castle to Frater including Fareham Creek i.e. north of the dashed line shown in Figure 4.1 above.

The Solent European Marine Site (Specified Areas) Towed Fishing Gear Emergency Byelaw came into force on 19th April 2013 under which shellfish dredging is also banned within the Solent Seagrass Protection Areas identified in the Sampling Plan, Figures 3.1 and 3.2. A Southern IFCA Prohibition of Gathering (Sea Fisheries Resources) In Seagrass Beds byelaw is also anticipated to be in force in the near future.

The IFCA also intend to ban both dredging and hand gathering of shellfish from all seagrass areas in the harbour sometime before the end of 2013. No shellfish harvesting is permitted in the main shipping route, specifically to the south of a line from the south west corner Whale Island to the Shell Pier (Queen's Harbour Master, Portsmouth, 2011).

All gathering of wild stocks is limited to the hours from 08:00 to 16:00. The IFCA may close any wild fishery at any time for reasons of stock preservation.

4.4. Hygiene Classification

Table 4.1 lists all classifications within Portsmouth Harbour from 2004 onwards.

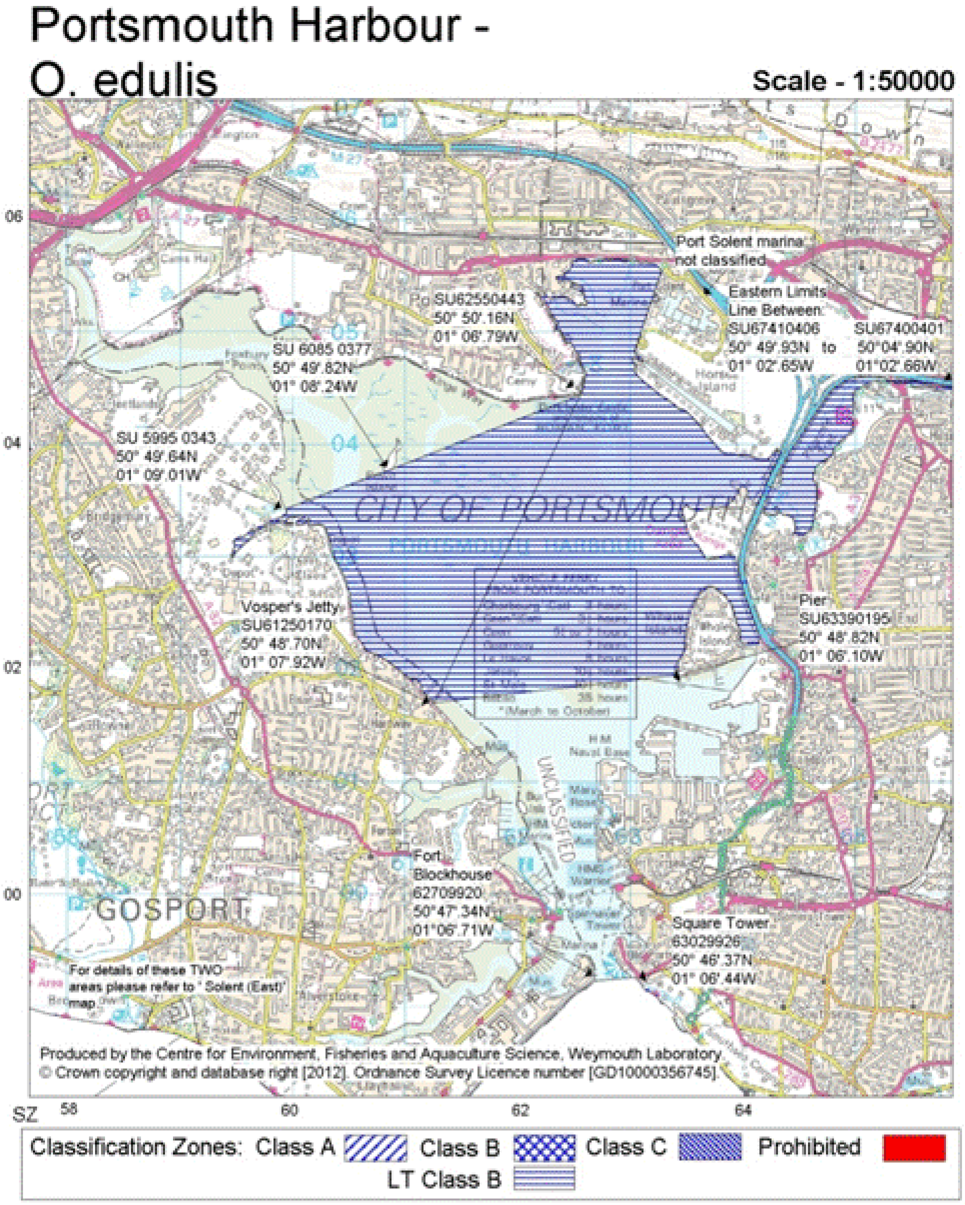
Table 4.1: Classification history for Portsmouth Harbour, 2004 onwards

Area	Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Eastern beds	*O. edulis*	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Eastern beds	*M. mercenaria*	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Western beds	*O. edulis*	B	B-LT	C	B	B	B	B-LT	B-LT	B-LT	B-LT
Western beds	*M. mercenaria*	B	B-LT	C	B	B	B	B-LT	B-LT	B-LT	B-LT

LT denotes long term classification

In 2006 the western beds received a C classification, but aside from this B classifications have been held throughout recent years. The hard clam classification is based on native oyster sample results, and the hard clams themselves have never been sampled. Manila clams, native clams, and cockles have never been classified, although they are taken from the harbour and presumably marketed somewhere on a regular basis. Manila clams and cockles 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.). Cockles and *Tapes* spp. will therefore require sampling and classification so they can be marketed in compliance with the hygiene legislations.

The current classification extends into Ports Creek, which is a narrow tidal channel connecting Portsmouth and Langstone Harbour. A combination of low bridges, shallow water and obstructions would prevent dredging in this creek.



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

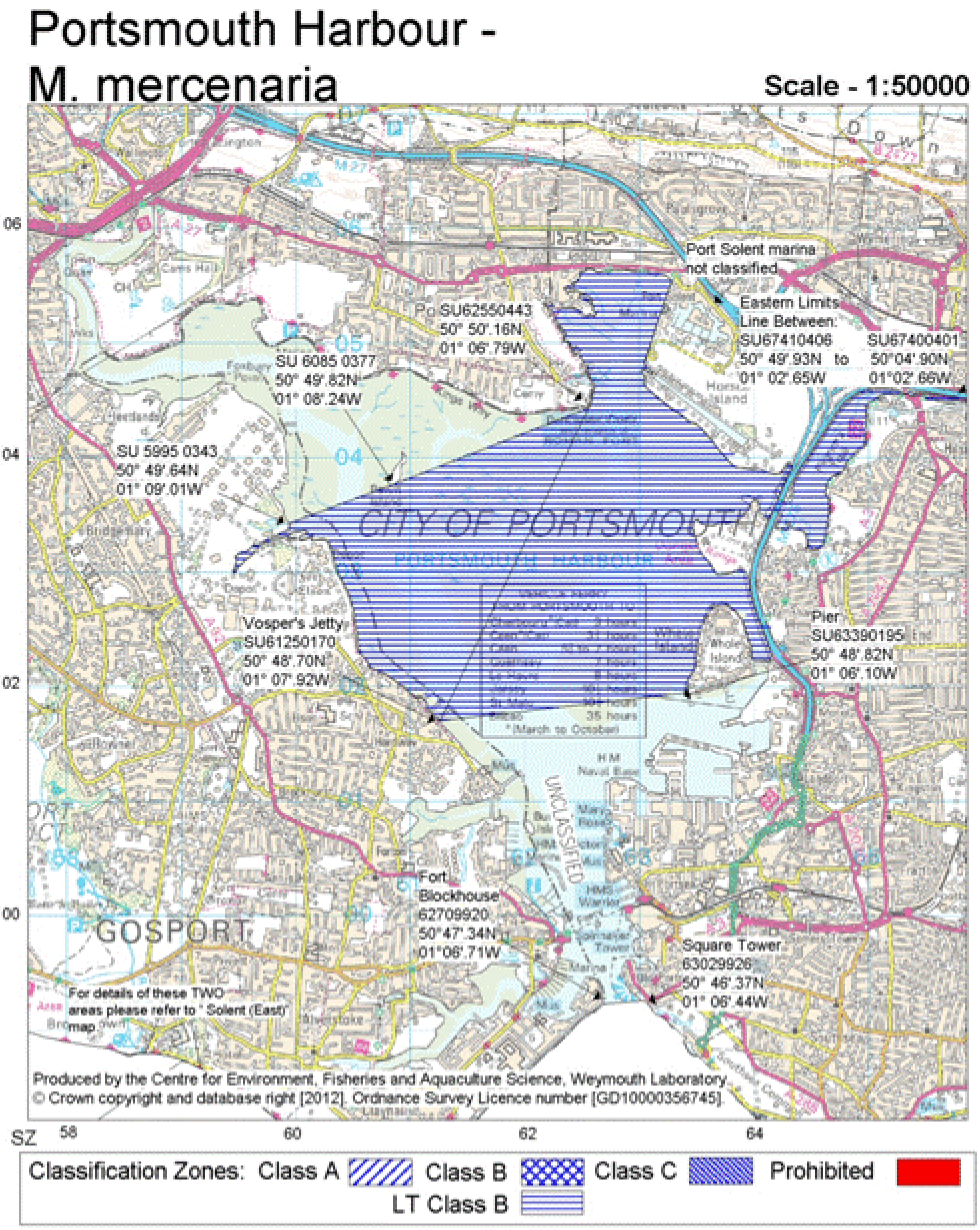
The areas delineated above are those classified as bivalve mollusc production areas under EU Regulation 854/2004.

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

N.B. Lat/Longs quoted are WGS84
Separate map available for M. mercenaria at Portsmouth

Food Authority: Portsmouth Port Health Authority

Figure 4.2: Current native oyster classifications



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N.B. Lat/Longs quoted are WGS84
Separate map available for O. edulis at Portsmouth

Food Authority: Portsmouth Port Health Authority

Figure 4.3: Current hard clam 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-1 Fluid and Intravalvular Liquid (FIL)	None
B[3]	Live bivalve molluscs from these areas must not exceed the limits of a five-tube, three dilution MPN test of 4,600 *E. coli* 100g-1 FIL in more than 10% of samples. No sample may exceed an upper limit of 46,000 *E. coli* 100g-1 FIL	Purification, relaying or cooking by an approved method
C[4]	Live bivalve molluscs from these areas must not exceed the limits of a five-tube, three dilution Most Probable Number (MPN) test of 46,000 *E. coli* 100g-1 FIL	Relaying for, at least, two months in an approved relaying area or cooking by an approved method
Prohibited[6]	>46,000 *E. coli* 100g-1 FIL[5]	Harvesting not permitted

[1] The reference method is given as ISO 16649-3.
[2] By cross-reference from EC Regulation 854/2004, via EC Regulation 853/2004, to EC Regulation 2073/2005.
[3] From EC Regulation 1021/2008.
[4] From EC Regulation 854/2004.
[5] This level is not specifically given in the Regulation but does not comply with classes A, B or C. The competent authority has the power to prohibit any production and harvesting of bivalve molluscs in areas considered unsuitable for health reasons.
[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

5.1. 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.

5.2. 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. Continuing classification is therefore required for the currently classified area, 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. Whilst regular monthly monitoring throughout the year is generally preferable, the first two months of the closed season need not necessarily be sampled, assuming all other 10 months are successfully sampled.

Manila clams, native clams and American hard clams are all present within the harbour, and are exploited via dredging. Dredge catches are dominated by Manila clams, with some bycatch of hard clams and native clams. All three species are thought to be present throughout the intertidal areas of the inner harbour. Manila clams, which make up the bulk of catches are currently unclassified, as are native clams. The productivity of this fishery has declined significantly in recent years. Vessels now tend to target the areas of higher elevation in the inner eastern part of the harbour, where the remaining clam concentrations are located, although they will fish other areas from time to time.

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 (Younger and

Reese, 2011) 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. It is a mixed fishery, with only a small proportion of hard clams in the catches. A hard clam classification derived from sample results from *Tapes* spp would make best use of LEA resources by avoiding additional sampling laboratory costs. This strategy would ensure that the classification is suitably protective of public health, and avoid the possibility of different classifications for different species caught in the same dredge. It may, however result in a poorer classification for the hard clam bycatch than would otherwise result if they were monitored separately.

Cockles are also exploited commercially within the harbour, but to a much lesser extent than the clams. Their distribution and status is uncertain, but they are likely to be widely distributed throughout the intertidal areas in a similar way to clams. There is a closed season for cockles from February to April. Cockles accumulate *E. coli* to similar levels as Manila clams (Younger and Reese, 2011). The sampling plan for *Tapes* spp. may therefore be used to classify cockles as well, saving the LEA the expense of sampling and monitoring cockles separately.

There is an area where dredging is prohibited for conservation reasons in the innermost western part of the harbour. Also, dredging is not permitted by the harbourmaster in the main shipping channel (i.e. anywhere south of Whale Island). These areas will not require classification, and have already been excluded from the current classifications. There are also a few smaller areas of seagrass extending into the middle reaches of the harbour, within which the IFCA has prohibited dredging and hand digging of shellfish via new byelaws. It has therefore been recommended that these areas are excluded from classified zones to avoid any potential confusion regarding the legality of harvesting shellfish within them. They do not coincide with any of the subtidal oyster beds but it is likely that they hold stocks of clams and cockles.

5.3. Pollution Sources

Freshwater Inputs

Portsmouth Harbour has a hydrological catchment of about 159 km^2, of which the upper and middle reaches are rural in character, and the lower reaches are largely urbanised. In the upper reaches of the catchment, flows of water are through chalk aquifers of the South Downs rather than surface watercourses. The middle and lower reaches of the catchment are mainly underlain by clays, and where the geology changes springs emerge and flows are via surface watercourses. There is one main river discharging to the harbour (the Wallington) which drains the middle reaches and much of the lower western reaches of the catchment, and discharges to the head of the Fareham channel. The rest of the urban areas surrounding the harbour are drained by a large number of small watercourses and drains. In geographical terms the main influence of runoff will therefore be in the Fareham channel, but there are a large number of smaller urban drainage outfalls of varying sizes that may create small localised hotspots of contamination at times.

Flow gauging records from the Wallington River indicate that there is significant seasonal and day to day variation in discharge. The average discharge rate is relatively minor, at around 0.6 m^3/sec. In recent years, the highest recorded discharge was just over 20 m^3/sec, although this was an exceptional event, and for 90% of the time flows do not exceed 1.35 m^3/sec. Flows were considerably higher on average during the colder months of the year, with peak flow events generally occurring from November to February. During the warmer months, flows were around base levels for much of the time, with sporadic elevated flow events. The EA have undertaken some limited bacteriological monitoring of Wallington River and surface water outfalls, however this was not available at the time of requesting data for this assessment, nor is any companion flow data available for these sampling stations, and so it is not possible to estimate the bacterial loading it typically delivers to the harbour.

There is little information available on the many minor surface water inputs to the harbour, aside from that obtained during the shoreline survey, which was undertaken during hot and dry conditions. They discharge via a large number (around 100) of pipes and engineered outfalls of varying sizes. A large proportion of these were not flowing at the time. Some of the flowing outfalls were sampled, and most contained relatively low concentrations of *E. coli* (<500 cfu/100ml). The three exceptions to this, containing between 8,000 and 150,000 *E. coli* cfu/100ml were believed to receive inputs from intermittent sewage discharges. Given the relatively impermeable nature of the urban fabric they drain, and their small sizes, these surface water outfalls are likely to respond rapidly to rainfall. Many will only discharge intermittently. As urban runoff typically carries quite high levels of faecal indicator bacteria these represent potentially significant but highly variable sources of contamination. They are all likely to respond to rainfall in a broadly similar manner. As there are many of these minor outfalls widely distributed around the harbour it will not be possible to directly capture the effects of all with the sampling plan. RMPs located by the larger and more continuously active outfalls should be reasonably representative of most.

Human Population

Total resident population within the Portsmouth Harbour catchment area was around 410,000 at the time of the last census (2011). There is a marked division between the upper catchment, which is rural and supports very low population densities, and the areas surrounding the harbour, which are heavily urbanised and support high population densities. Highest population densities are at Portsmouth, on the eastern shore of the harbour but Portchester to the north and Fareham and Gosport to the west also support high densities. Therefore, almost the entire shoreline of the harbour is susceptible to impacts from urban runoff. Impacts from sewage discharges will depend on the local sewerage infrastructure.

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

Sewage Discharges

The majority of sewage generated in the Portsmouth Harbour catchment is treated at either the Peel Common STW or Budds Farm STW. Both of these sewage works lie outside of the hydrological catchment, Peel Common STW receives UV disinfection and Budds Farm receives secondary treatment, and discharge via long sea outfalls to the Solent. As such, they should be of no impact on Portsmouth Harbour.

There is only one relatively small water company sewage works within the catchment which serves the village of Southwick. It provides secondary treatment for a consented dry weather flow of 540 m^3/day, and discharges to the River Wallington about 7km upstream of the tidal limit. Its impacts will therefore be felt alongside other catchment sources such as agricultural runoff delivered to the head of the Fareham channel by the river. An estimate of the bacterial loading it generates is around 1.8×10^{12} faecal coliforms/day, although there will be some dieoff during transit to the harbour.

Although the main sewage treatment works do not discharge to the harbour, there are 62 consented intermittent discharges within the hydrological catchment of the harbour associated with the various sewer networks. These are mainly concentrated around Gosport and Fareham, although there are a few at Portchester and around the Portsmouth dock area. Additionally, there are several discharging to the middle and upper reaches of the River Wallington. Around 70% of these discharges have spill event monitoring equipment. An examination of recent spill records (2008-2012) showed that all but two of the monitored outfalls spilled for less than 0.5% of the time. Forest Road Denmead No. 2 CSO, which discharges to the River Wallington about 14km upstream of the tidal limit, spilled for 6.9% of this period. A small number of relatively long duration spills which occurred during the autumn and winter only were recorded here. Impacts from this intermittent discharge may be captured by any RMPs located to capture catchment sources delivered by the River Wallington. Bridgefoot PS, which discharges to Portsmouth Harbour near where the River Wallington enters it spilled for 2.9% of this period. There were a large number of short spill events recorded here, the majority of which occurred in the winter. Again, this discharge will impact on the fishery with a similar spatial profile to the River Wallington. For those without event monitoring it is difficult to assess their potential impacts aside from noting their location and potential to spill untreated sewage.

Intermittent discharges create issues in management of shellfish hygiene however infrequently they spill. Their impacts are not usually captured during a year's worth of monthly monitoring from which the classification is derived as they only operate occasionally. Thus when they do have a significant spill, heavily contaminated shellfish may be harvested under a better classification than the levels of *E. coli* within them may merit. A reactive system alerting relevant parties to spill events in real time may therefore convey better public health protection.

Although the vast majority of properties are connected to mains sewage, there are also a few private discharges some of which may be of significance. The majority of these are small, serving one or two properties, with treatment from septic tanks or package plants. Some discharge to water, and others discharge to soakaway. Most are located in the upper reaches of the River Wallington catchment, and those discharging to this watercourse will contribute to the bacterial loading it carries. Those discharging to soakaway should be of no impact, assuming they are functioning correctly. There is a relatively large private discharge just outside of the mouth of the harbour (Children's Corner, consented to discharge up to $67m^3$/day), the plume from which may be carried into the harbour on the flood tide. This lies over 4km from the fishery in the inner harbour however, so it will not create a significant hotspot of contamination within the classified area.

There are three intermittent discharges to the north east corner of Langstone Harbour, which may have some impacts on the Tipner Lake area via Ports Creek. Two are monitored (Cosham Court Lane and Mainland Drayton) and an examination of recent spill records undertaken during a sanitary survey of Langstone Harbour (Cefas, 2013) showed that they spilled for 4% and <0.5% of the time respectively.

Agriculture

The majority of agricultural land within the hydrological catchment of Portsmouth Harbour is arable, although there are some areas of pasture, mainly in its middle to upper reaches. Land cover in the lower catchment is generally urban, and there are not thought to be any pastures used for grazing in the immediate vicinity of the harbour. Numbers and densities of livestock within the catchment are relatively low, with totals of 4996 cattle, 2435 sheep, 6383 poultry, and an undisclosed but presumably low number of pigs recorded in the 2010 agricultural census. No livestock were observed during the shoreline survey. As such, the impacts of agriculture on shellfish hygiene in Portsmouth Harbour are likely to be relatively low.

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. The only watercourse likely to be impacted to a significant extent is the River Wallington. Agricultural contamination from the arable areas in the uppermost reaches of the catchment area is unlikely to be of any significance to the harbour as water movements here are via chalk aquifers.

There is likely to be seasonality in levels of contamination originating from livestock. Numbers of sheep and cattle will increase significantly in the spring, with the birth of lambs and calves, and decrease in the autumn when animals are sent to market. During 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

Boat traffic within Portsmouth Harbour is heavy, consisting of a mix of commercial shipping, naval vessels, cross channel ferries, a fishing fleet, and numerous recreational craft such as yachts and cabin cruisers. The international port receives about 3000 shipping movements a year. The naval base is home to around two thirds of the navy's surface ships. The fishing fleet consists of about 20-30 vessels and is based in the harbour mouth. There are 8 marinas/quays used by recreational craft, of which 6 are around the harbour mouth, with two in the innermost reaches of the harbour (Port Solent Marina in the east, and Fareham Marina in the west). None of the marinas offer sewage pump-out facilities. Moorings are mainly concentrated along the western harbour channel, all the way up to Fareham. There are also some moorings in the north east corner of the harbour, by Port Solent Marina.

Commercial shipping is not permitted to make overboard discharges within 3 nautical miles of land so the cargo ships and ferries should be of no impact. It is uncertain what impact the naval vessels may have. They are exempt from the regulations applying to merchant shipping, but it is likely that in practice they do not make sewage discharges to the harbour. The propeller washes and wakes created by larger vessels may however resuspend contamination held in the sediment, and this will mainly occur in the vicinity of the docks and ferry terminals. Private vessels such as yachts, motor cruisers and fishing vessels of a sufficient size are likely to make overboard discharges from time to time. This may either occur when the boats are moored or at anchor, particularly if they are in overnight occupation, or while they are navigating through the estuary. Occupied yachts on pontoon berths may be less likely to make overboard discharges as facilities on land are easier to access. The areas that are at highest risk from microbiological pollution therefore include mooring areas and the main navigation routes through the estuary, i.e. the subtidal channels. 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.

Wildlife

Portsmouth Harbour contains intertidal mudflats, seagrass beds, saltmarsh and sand and shingle banks. 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 12,810 for the five winters up to 2010/11. Grazers such as geese will graze on saltmarsh and seagrass areas but also feed on playing fields adjacent to the harbour and arable fields inland. Their impacts will be via runoff from or tidal inundation of these areas. RMPs within or near to the drainage channels from saltmarsh areas will be best located to capture contamination from these birds. Some grazers (e.g. Brent Geese) also forage on seagrass beds. 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 nationwide survey in 2000/01 did not identify any seabird breeding colonies within the harbour. Black headed gulls are however reported to be in abundance at Tipner Headland. 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 Tipner Headland.

There is a small colony of about 25 harbour seals which reside in the eastern Solent area. Their favoured haul-out sites are located in Langstone and Chichester Harbours. Seals forage widely and therefore are likely to enter Portsmouth Harbour from time to time. Whilst seals 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.

Domestic animals

Dog walking takes place on beaches and paths adjacent to the shoreline predominantly on the northern shore of the survey area and could represent a potential source of diffuse contamination to the near shore zone. The intensity of dog walking is likely to be higher closer to the more urban areas. As a diffuse source, this will have little influence on the location of RMPs.

Summary of Pollution Sources

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

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

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

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

In summary, the main single source is the River Wallington, which discharges to the head of the western channel a considerable distance up from the area requiring classification. There are multiple small sources of urban runoff all around the harbour which are likely to be responsible for delivering significant loadings of faecal indicators at times. The intermittent sewage discharges to the harbour, where monitored, only spill infrequently and so their impacts are unlikely to be captured via monthly monitoring. Birds and boats may be a significant source at different times of the year, but may be treated as a diffuse source.

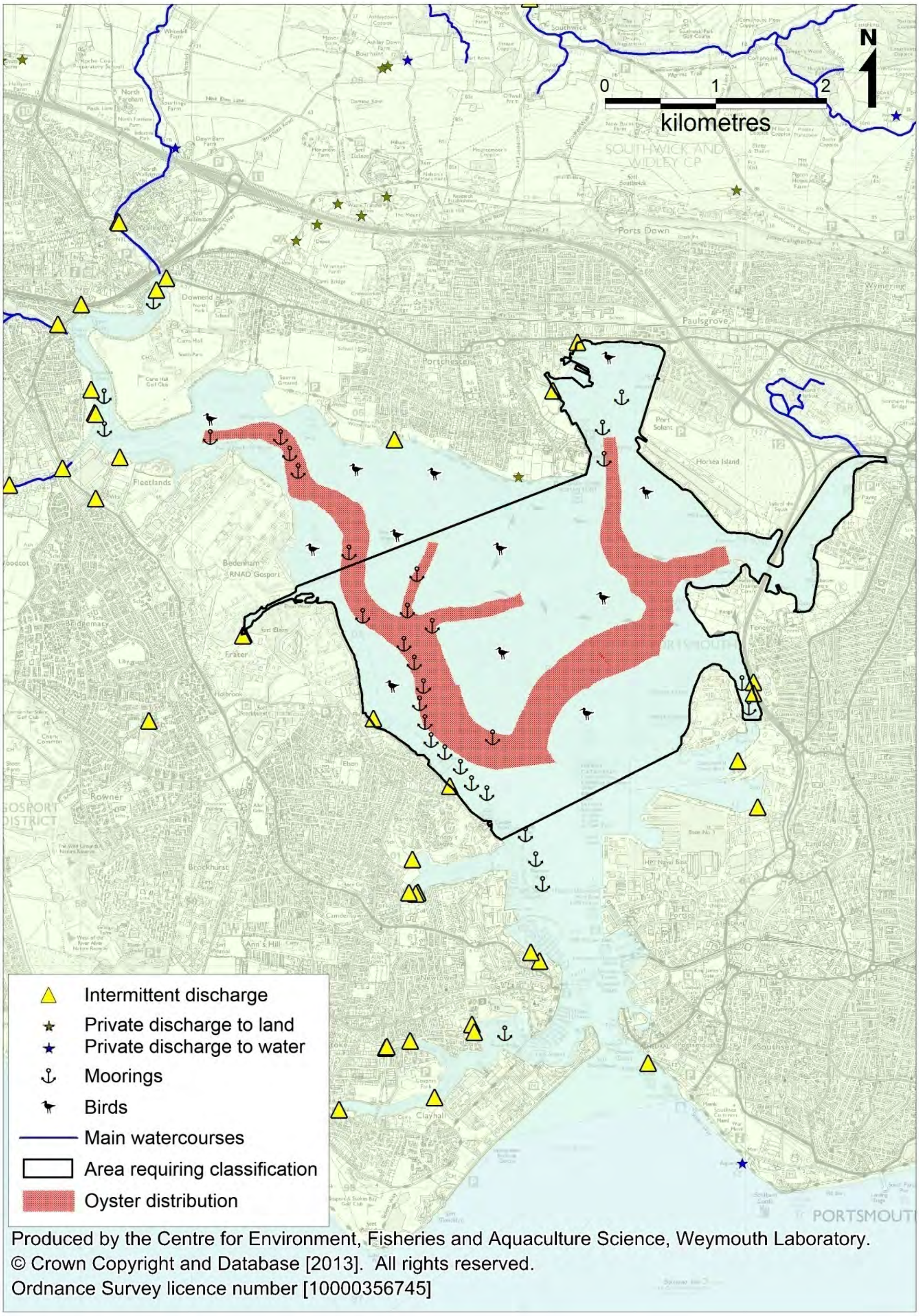

Figure 5.1: Summary of main contaminating influences

5.4. Hydrography

Portsmouth Harbour covers an area of about 16 km^2, of which about 60% is intertidal. It has a relatively deep and narrow mouth flanked by dockyards and urban areas. Inside from the mouth it widens significantly and the main channel splits into a further two channels which head north west (Fareham Channel) and north east (Portchester Channel). The channels become progressively shallower, and there are a number of smaller subtidal and intertidal creeks/channels emanating from them. The inner harbour is largely intertidal, mainly consisting of mudflats. The only significant freshwater input is to the head of the Fareham Channel. There is a connection from the north east harbour to neighbouring Langstone Harbour which dries at low water and is as narrow as 20m in width in places.

Tidal amplitude is 3.9m on spring tides and 1.9m 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, peaking at just over 2m/s during spring ebb tides according to a tidal diamond in the mouth. Further in the harbour, but still in the main navigation channel by the naval base currents are considerably slower, peaking at just under 0.8m/s. Currents are likely to be slower still in the inner reaches of the harbour, particularly over the intertidal areas, as evidenced by the decreasing sediment particle sizes. This suggests that sources of contamination in the intertidal areas of the inner harbour will have more acute but localised effects than those discharging to the deeper channels and the harbour mouth.

Although the vast majority of water exchange occurs via the mouth, some exchange of water through the secondary connection to Langstone Harbour has been documented. Exchange through the Ports Creek is in a net westerly direction, i.e. into Portsmouth Harbour. Sources discharging to this channel and possibly the north west corner of Langstone Harbour may therefore be of some impacts in the Tipner Lake area.

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 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, although slightly reduced salinities were recorded at times in the upper reaches of the Fareham Channel, to which the River Wallington discharges. Despite there being little variation in salinity, the concentration of faecal indicator bacteria was negatively correlated with salinity at a monitoring point off Frater, in the Fareham channel. This suggests that although the volumes of runoff received by the harbour are small, land runoff is a significant contaminating influence.

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.

5.5. Summary of Existing Microbiological Data

Portsmouth Harbour has been subject to some microbiological monitoring over recent years, deriving from Environment Agency shellfish waters monitoring and shellfish flesh monitoring for hygiene classification purposes. Figure 5.2 shows the locations of the monitoring points referred to in this assessment. Results of samples taken from 2003 onwards were considered as there have been no major improvements to local sewerage infrastructure since this time.

Figure 5.2: Microbiological sampling locations

Only one location (Portsmouth Harbour) was sampled under the shellfish waters monitoring programme, where water samples were taken on a quarterly basis and enumerated for faecal coliforms. The geometric mean result was 15 faecal coliforms/100ml, and the maximum recorded was 577 faecal coliforms/100ml. Since 2002, there was a peak in results in 2007/8, a decline through to 2010, and an increasing trend since then. A strong seasonality was found, with significantly higher results during the winter than during the spring and summer. No influence of tidal state, either across the high/low or the spring/neap tidal cycles was found. A significant influence of rainfall was found. The strongest influence arose one day after the rainfall event, perhaps due to runoff from the bordering urban areas. There was also a weaker more delayed influence which may be due to runoff from the larger River Wallington catchment. Although salinity only ranged from 31 to 35ppt, there was a significant negative correlation with faecal coliform concentrations. This suggests that runoff, although relatively minor in terms of the volumes involved, is a significant contaminating influence.

Under the hygiene classification monitoring programme, three RMPs have been sampled and tested on a monthly basis for *E. coli* levels in native oyster flesh. Of these, one in the eastern arm of the inner harbour has been sampled throughout the period 2003 to present (Portchester Lake). In the western arm, Peewit Island was sampled from 2003 to 2011, and in 2011 the sampling location was moved south to Post 50, which has been sampled from 2011 to present. Caution should therefore be exercised comparing the two western RMPs as they were sampled during different periods.

The average result was very similar at the three RMPs, and did not differ significantly between them. A lower proportion of results exceeded 4,600 MPN/100g at Portchester Lake compared to the two RMPs in the west channel. One prohibited level result was recorded at Peewit Island. This tendency for higher peak results in the western arm may be due to the River Wallington, which discharges to the head of this channel. Comparisons of paired (same day) samples taken from Portchester Lake and the other two RMPs revealed significant correlations on a sample by sample basis in both cases. Neither were particularly strong correlations, but they do suggest that the two channels are influenced by broadly similar sources.

The levels of *E. coli* in native oysters have remained fairly stable since 2003. Significant seasonal variations at Post 50 and Peewit Island, where results were significantly higher in the autumn compared to the winter and spring. There was no significant seasonal pattern at Portchester Lake, where levels of *E. coli* were similar on average throughout the year. This suggests that sources with differing seasonality are influencing the east and west channels.

A significant correlation between *E. coli* levels and the state of the tide on the high/low tidal cycle was found at Portchester Lake only, where there appeared to be a weak tendency for higher results during the flood tide. This suggests that sources to the south are of some influence. A correlation between *E. coli* levels and the state of the tide on the spring/neap tidal cycle was found at Pewit Island only. This correlation was weak, but a tendency for fewer low results during the larger, spring tides could tentatively be seen when the data was plotted. A significant influence of rainfall was found at all three RMPs, although there was some difference in the temporal profile of the responses. Levels of *E. coli* were influenced by rainfall very rapidly at Pewit Island and continued to be affected for several days. Portchester Lake oysters were also affected by rainfall but not as quickly as at Peewit Island. Little influence of rainfall was seen at Post 50 and the response was delayed, but much fewer samples were taken from here.

Appendices

Appendix I. Human Population

Figure I.1 shows population densities in census output areas within or partially within the Portsmouth Harbour catchment area, derived from data collected from the 2011 census.

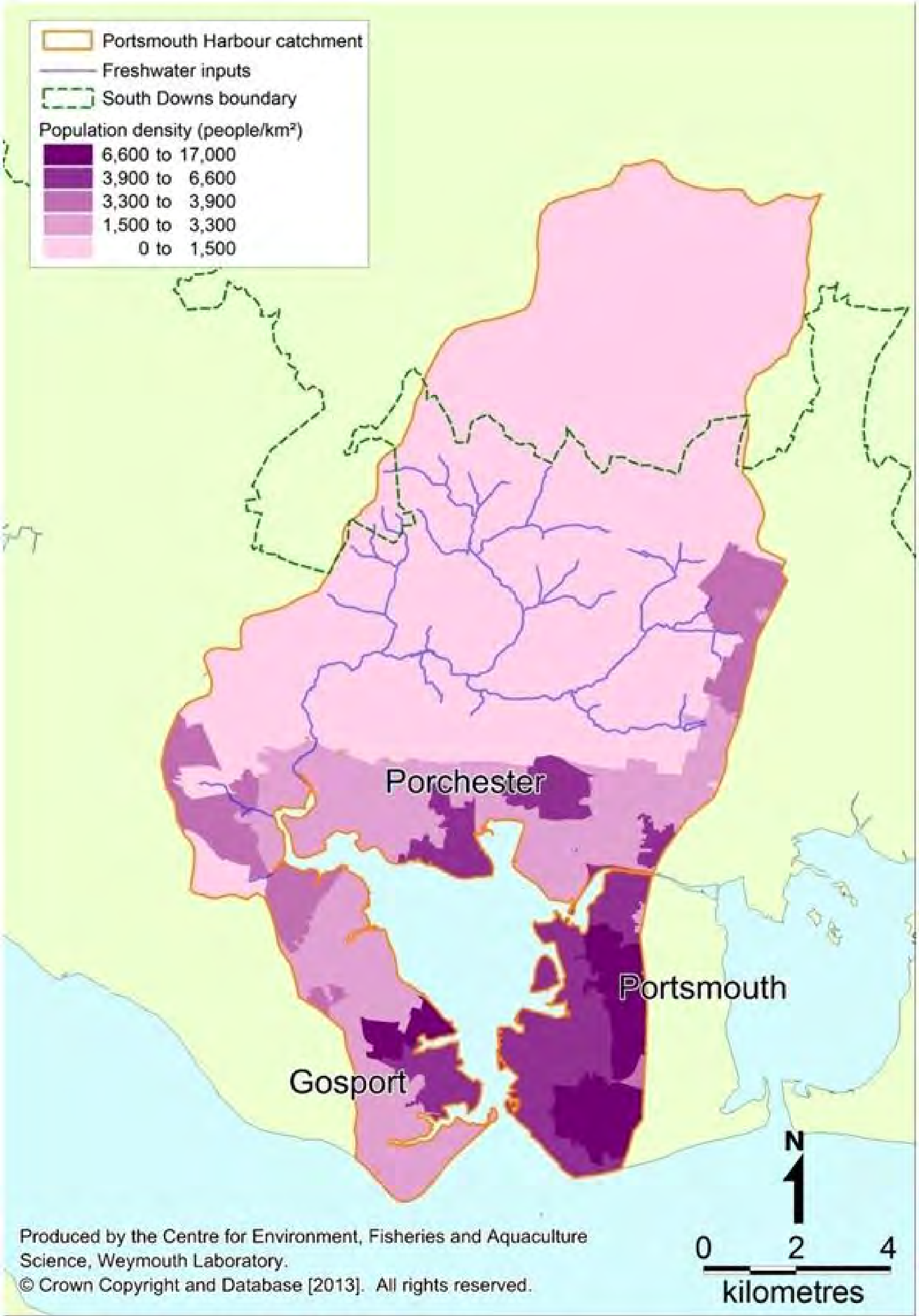

Figure I.1: Human population density in census areas in the Portsmouth Harbour catchment.

Total resident population within the Portsmouth Harbour catchment area was approximately 410,000 at the time of the last census. Figure I.1 indicates that population densities are highest in the areas directly adjacent to the harbour, especially around Portsmouth and Gosport. Much of Portsmouth exceeds 10,000 people/km², and parts of Gosport have population densities of around 7,200 people/km². In addition, Portchester to the north of the Harbour has a population density of approximately 4,000 people/km². Most of the freshwater inputs flow through areas with relatively low population densities and therefore the harbour probably has a high risk from urban runoff. Impacts from sewage will depend on the nature and locations of discharges associated with these settlements and are discussed in detail in Appendix II.

Approximately 23% of the catchment is covered by South Downs National Park. This explains the relatively low population densities in the northern part of the catchment. However this number is likely to increase during the summer months when tourists visit the South Downs for its rich English history and to take part in outdoor activities such as walking or cycling.

Portsmouth hosts several tourist attractions such as the historical dockyard and the Spinnaker Tower and Portsmouth Cathedral. Together, these attractions had almost 1 million visitors in 2009. Other tourist attractions within the catchment attracted a total of 660,000 visitors in 2009 (Hampshire CC, 2011).

Although accurate tourism figures are not known for the majority of the catchment it is likely that the numbers are relatively high in the summer months due to it being situated within a national park in the north, seaside resorts in the south (Southsea) and in close proximity to Portsmouth. It can therefore be assumed that there will be a significant seasonal variation of population levels in the catchment, and the volumes of effluent received by sewage treatment works serving the area would be expected to fluctuate accordingly.

Appendix II. Sources and Variation of Microbiological Pollution: Sewage Discharges

Details of all consented sewage discharges in the Portsmouth Harbour hydrological catchment were taken from the most recent update of the Environment Agency national permit database (March 2013). These are mapped in Figure II.1.

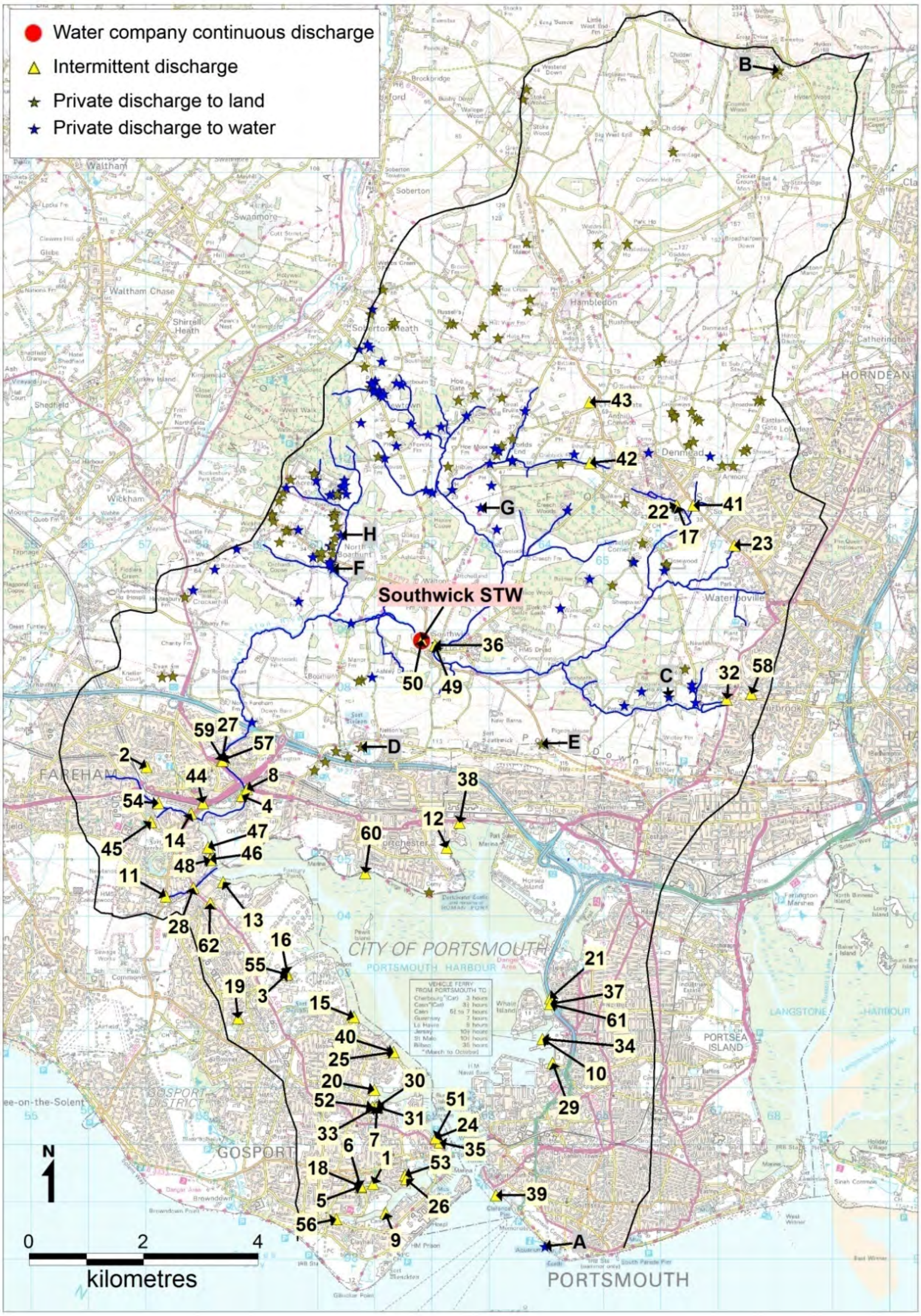

Figure II.1: Sewage discharges to the Portsmouth Harbour catchment

The majority of sewage generated in the Portsmouth Harbour catchment is treated at either the Peel Common STW or Budds Farm STW. Both of these sewage works lie outside of the catchment, Peel Common receives UV disinfection and Budds Farm receives secondary treatment, and discharge via long sea outfalls to the Solent. As such, they should be of no impact on Portsmouth Harbour. There is only one relatively small water company sewage works within the catchment (Table II.1) which serves the village of Southwick. It discharges to the River Wallington about 7km upstream of the tidal limit, and will contribute significantly to the bacterial loading delivered to the harbour by this watercourse.

Table II.1: Details of continuous water company sewage works

Name	NGR	Treatment	Dry weather flow (m^3/day)	Estimated bacterial loading (cfu/day)*	Receiving environment
Southwick STW	SU6182008820	Biological filtration	540	1.78×10^{12}	River Wallington

*Faecal coliforms (cfu/day) based on geometric base flow averages from a range of UK STWs providing secondary treatment (Table II.2).
Data from the Environment Agency

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

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

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

In addition to the continuous sewage discharges, there are a large number of intermittent water company discharges associated with the sewerage networks also shown on Figure II.1. Most are in Fareham and Gosport. Details of these are shown in Table II.3, where discharges highlighted in yellow have spill event monitoring.

Table II.3: Intermittent discharges within the Portsmouth Harbour catchment and summary spill information (January 2008 to March 2012)

No.	Name	Grid reference	Receiving water	No. events recorded	Total duration (hrs)	% time spilling				
						Spr	Sum	Aut	Win	Total
1	Alver Road Gosport PS&CEO	SZ6097099320	Portsmouth Harbour	0	-	-	-	-	-	-
2	Arundel Drive SO	SU5701006600	Black Brook	3	4.06	-	-	<0.1%	<0.1%	<0.1%
3	Brewers Lane Gosport CSO	SU5947002990	Portsmouth Harbour	13	145.20	0.7%	-	0.4%	0.4%	0.4%
4	Bridgefoot PS	SU5868006100	Portsmouth Harbour	189	1087.78	0.1%	0.1%	0.5%	10.2%	2.9%
5*	Bury Cross Hospital PS	SZ6076099270	Portsmouth Harbour							
6	Bury Road Gosport CEO	SZ6075099260	Portsmouth Harbour	1	0.17	<0.1%	-	-	-	<0.1%
7	Cambridge Road/Brockenhurst Road PS	SU6104000660	Portsmouth Harbour	1	7.07	0.1%	-	-	-	<0.1%
8*	Cams Hill Fareham CSO	SU5877006210	Portsmouth Harbour							
9	Clayhall Road/Dolphin Way PS	SZ6119098810	Portsmouth Harbour	0	-	-	-	-	-	-
10	Commercial Road/Rudmore Road CSO	SU6393001850	Portsmouth Harbour							
11	Cotswold Walk CSO	SU5735004340	Hoeford Stream							
12	Cow Lane Portchester CEO	SU6226005190	Portsmouth Harbour	0	-	-	-	-	-	-
13	Cynamid PS (Lederle Lane)	SU5835004590	Portsmouth Harbour	4	16.82	<0.1%	-	0.2%	-	<0.1%
14	Elmhurst Road (Compass Point) CSO	SU5779005790	Black Brook	1	66.67	0.7%	-	-	-	0.2%
15	Elson Waste Water PS	SU6064002230	Portsmouth Harbour	0	-	-	-	-	-	-
16	Fareham Road Gosport O/S 68 CSO	SU5947002990	Portsmouth Harbour	5	78.10	-	-	-	0.8%	0.2%
17	Forest Road Denmead No. 2 CSO	SU6629011160	River Wallington	8	2565.00	-	-	14.6%	12.7%	6.9%
18	Foster Road PS CSO	SZ6076099270	Portsmouth Harbour	1	0.80	-	-	-	<0.1%	<0.1%
19	Green Crescent Overflow	SU5861002210	Unnamed watercourse							
20	Grove Road Gosport PS CSO	SU6099000960	Portsmouth Harbour	52	91.42	<0.1%	0.1%	0.5%	0.4%	0.2%
21	Gruneison Road Storm PS	SU6407002560	Portsmouth Harbour	0	-	-	-	-	-	-
22	Hambeldon (Denmead) PS	SU6627011180	Wallington trib.	5	128.50	0.1%	-	0.1%	1.1%	0.3%
23	Hambeldon Road (Waterlooville)	SU6728010480	Wallington trib.	65	141.99	0.6%	0.2%	0.3%	0.5%	0.4%
24	Harbour Road Gosport CEO	SU6206000120	Portsmouth Harbour	0	-	-	-	-	-	-
25	Hardway CEO, Priory Road Gosport	SU6133001620	Portsmouth Harbour	5	5.65	-	-	<0.1%	<0.1%	<0.1%
26*	Henry Street PS	SZ6155099400	Portsmouth Harbour							
27	High Street Fareham CSO	SU5833006720	River Wallington	0	-	-	-	-	-	-
28	Hoeford Fareham CEO	SU5783004490	Portsmouth Harbour	12	116.89	-	-	0.8%	0.5%	0.3%
29	Holbrook Road/Pyning Street CSO	SU6411001430	Portsmouth Harbour	0	-	-	-	-	-	-

No.	Name	Grid reference	Receiving water	No. events recorded	Total duration (hrs)	% time spilling				
						Spr	Sum	Aut	Win	Total
30	Lees Lane Gosport CEO	SU6104000663	Portsmouth Harbour	0	-	-	-	-	-	-
31	Lees Lane PS	SU6104000660	Portsmouth Harbour							
32	Lone Valley/Serpentine Road CSO	SU6715007790	Wallington trib.							
33	Middlecroft Lane Gosport CSO	SU6102000650	Portsmouth Harbour	0	-	-	-	-	-	-
34	Mile End Road CSO	SU6393001850	Portsmouth Harbour	0	-	-	-	-	-	-
35	Mumby Road Gosport WPS/CEO	SU6214000040	Portsmouth Harbour	0	-	-	-	-	-	-
36	Newmans Bridge Southwick CEO	SU6205008730	River Wallington							
37	North End Avenue Portsmouth CSO	SU6407002460	Portsmouth Harbour	6	7.25	-	-	<0.1%	0.1%	<0.1%
38	Paulsgrove PS	SU6248005630	Portsmouth Harbour	0	-	-	-	-	-	-
39	Pier Road PS	SZ6312099120	Solent	3	13.94	-	-	0.1%	0.1%	<0.1%
40	Priory Road PS	SU6133001620	Portsmouth Harbour							
41	Pumping Station No. 1	SU6657011180	Wallington trib.							
42	Pumping Station No. 2	SU6476011920	Wallington trib.							
43	Pumping Station No. 3	SU6475012980	Wallington trib.							
44	Quay Street Fareham CSO	SU5800005970	Portsmouth Harbour	0	-	-	-	-	-	-
45	Redlands Lane Fareham CSO	SU5709005640	Black Brook	0	-	-	-	-	-	-
46	Salterns Lane Fareham CEO	SU5812004990	Portsmouth Harbour	10	166.30	-	-	1.8%	0.1%	0.4%
47	Salterns Lane Fareham O/S 12 CSO	SU5809005200	Portsmouth Harbour		-	-	-	-	-	-
48	Salterns Lane PS	SU5813004980	Portsmouth Harbour							
49	Sewage PS	SU6205008730	River Wallington							
50	Southwick STW	SU6182008820	River Wallington							
51	St Matthews Square Gosport CEO	SU6206000120	Portsmouth Harbour	0	-	-	-	-	-	-
52*	St Vincents PS	SU6096000660	Portsmouth Harbour							
53	The Anchorage Gosport CEO	SZ6153099470	Portsmouth Harbour	0	-	-	-	-	-	-
54	The Gillies Fareham CSO	SU5722005970	Black Brook	3	3.72	-	-	<0.1%	<0.1%	<0.1%
55	Tichbourne Way PS	SU5946002980	Portsmouth Harbour	0	-	-	-	-	-	-
56	Village Road Alvestoke PS CSO	SZ6033098700	Portsmouth Harbour	19	54.71	0.3%	<0.1%	0.3%	<0.1%	0.1%
57	Wallington Hill CSO	SU5833006720	River Wallington	0	-					-
58	Westbrook Grove Purbrook CEO	SU6758007880	Wallington trib.							
59	Wickham Road Fareham WPS CSO	SU5834006710	River Wallington	2	8.53	-	-	0.1%	-	<0.1%

No.	Name	Grid reference	Receiving water	No. events recorded	Total duration (hrs)	% time spilling				
						Spr	Sum	Aut	Win	Total
60	Wicor Mill Lane Portchester CEO	SU6083004750	Portsmouth Harbour	2	1.03	-	-	-	<0.1%	<0.1%
61	Widley Road Portsmouth CSO	SU6407002460	Portsmouth Harbour	6	6.67	-	-	<0.1%	0.1%	<0.1%
62	Wych Lane/Fareham Road Overflow	SU5813004220	Portsmouth Harbour	7	26.20	<0.1%	-	0.1%	0.1%	0.1%

Data from the Environment Agency

**Southern Water installed* event and duration monitoring *equipment on these discharges in March 2011, however spill report data was not received for them.* *Southern Water subsequently informed* Cefas *that the*se assets *have not spilled during the subsequent period of interest.*

For those without event monitoring it is difficult to assess their potential impacts aside from noting their location and potential to spill untreated sewage. For those with event monitoring the vast majority spilled for less than 0.5% of the period January 2008 to March 2012. Whilst these may be of occasional influence their impacts are very unlikely to be captured during monthly shellfish monitoring. Only two discharges spilled for more than 0.5% of the period. Forest Road Denmead No. 2 CSO, which discharges to the River Wallington about 14km upstream of the tidal limit, spilled for 6.9% of this period. A small number of relatively long duration spills which occurred during the autumn and winter only were recorded here. Bridgefoot PS, which discharges to Portsmouth Harbour near where the River Wallington enters it spilled for 2.9% of this period. There were a large number of short spill events recorded here, the majority of which occurred in the winter.

Although the vast majority of the survey area is served by water company sewerage infrastructure, there are also a number of private discharges some of which may be of significance. Where specified, they are generally treated by small treatment works such as package plants. The majority of these are small, serving one or two properties. Most are located in the upper reaches of the River Wallington catchment, and those discharging to this watercourse will contribute to the bacterial loading it carries. Those discharging to soakaway should be of no impact, assuming they are functioning correctly. Details of the larger private discharges (>5m^3/day maximum permitted flow) are presented in Table II.4.

Table II.4: Details of private sewage discharges of over 5m^3/day

Ref.	Property served	Location	Treatment type	Max. daily flow (m^3/day)	Receiving environment
A	Children's Corner	SZ6397098220	Unspecified	67	The Solent
B	Development at HMS Mercury	SU6806018780	Unspecified	23	Soakaway
C	Field adj to 1 Widley Walk	SU6614007830	Unspecified	5.6	Wallington trib.
D	Hampshire C.C.	SU6076006950	Unspecified	5	Soakaway
E	Portsdown Technology Park	SU6392007010	Unspecified	25	Soakaway
F	South Hampshire Country Club	SU6027010070	Package Plant	27	Wallington trib.
G	The Chairmakers Arms	SU6285011140	Unspecified	10	Wallington trib.
H	Wine Cross STW	SU6041010660	Unspecified	8	Wallington trib.

* Dry weather flow rather than maximum flow.
Data from the Environment Agency.

Most of the larger private discharges to water discharge to the River Wallington, so will add to the bacterial loading carried by this watercourse. Children's Corner discharges to the Solent just outside the mouth of Portsmouth Harbour, so any plume from this will be carried in on the flood tide.

Appendix III. Sources and Variation of Microbiological Pollution: Agriculture

The majority of agricultural land within the hydrological catchment of Portsmouth Harbour is arable, although there are some areas of pasture, mainly in its middle to upper reaches (Figure 1.2). Although Figure 1.2 indicates that there are two small pockets of pastures immediately adjacent to the harbour these areas of grassland are used for sports and recreation. 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.

Table III.1: Summary statistics from 2010 livestock census for the area draining to Portsmouth Harbour

Cattle		**Sheep**		**Pigs**		**Poultry**	
No.	Density (no/km^2)	No.	Density (no/km^2)	No.	Density (no/km^2)	No.	Density (no/km^2)
4,996	31.3	2.435	15.3	**	**	6,383	40.0

*** Data withheld for confidentiality as it relates to a small number of holdings.*
Data from Defra

The concentration of faecal coliforms excreted in the faeces of animals and humans 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 the 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.

There are small numbers of grazing animals (both sheep and cattle) within the catchment, as well as a few poultry. No livestock was recorded in the vicinity of the harbour during the shoreline survey. Given the small numbers the overall impact of livestock farming is likely to be minor. Almost all pasture is in areas drained directly by the River Wallington. 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 and middle reaches of the catchment. 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), so no impacts from arable agriculture in the upper catchment are anticipated. Only the main watercourse (River Wallington) is likely to be impacted to any significant extent by contamination from agricultural sources as all other surface water inputs to the harbour are small and drain non-agricultural land.

There is likely to be seasonality in levels of contamination originating from livestock. Numbers of sheep and cattle will increase significantly in the spring, with the birth of lambs and calves, and decrease in the autumn when animals are sent to market. During winter cattle may be transferred from pastures to indoor sheds, and at these times slurry will be collected and stored for later application to fields. Timing of these applications is uncertain, although farms without large storage capacities are likely to spread during the winter and spring. Poultry 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 of Microbiological Pollution: Boats

The discharge of sewage from boats is a potentially significant source of bacterial contamination of shellfisheries in Portsmouth Harbour. It contains a naval base, a commercial port, and several marinas, and so is used by a wide range of craft including military vessels, commercial shipping, a fishing fleet, and recreational boats such as yachts and cabin cruisers. Figure IV.1 presents an overview of boating activity derived from the shoreline survey, satellite images and various internet sources.

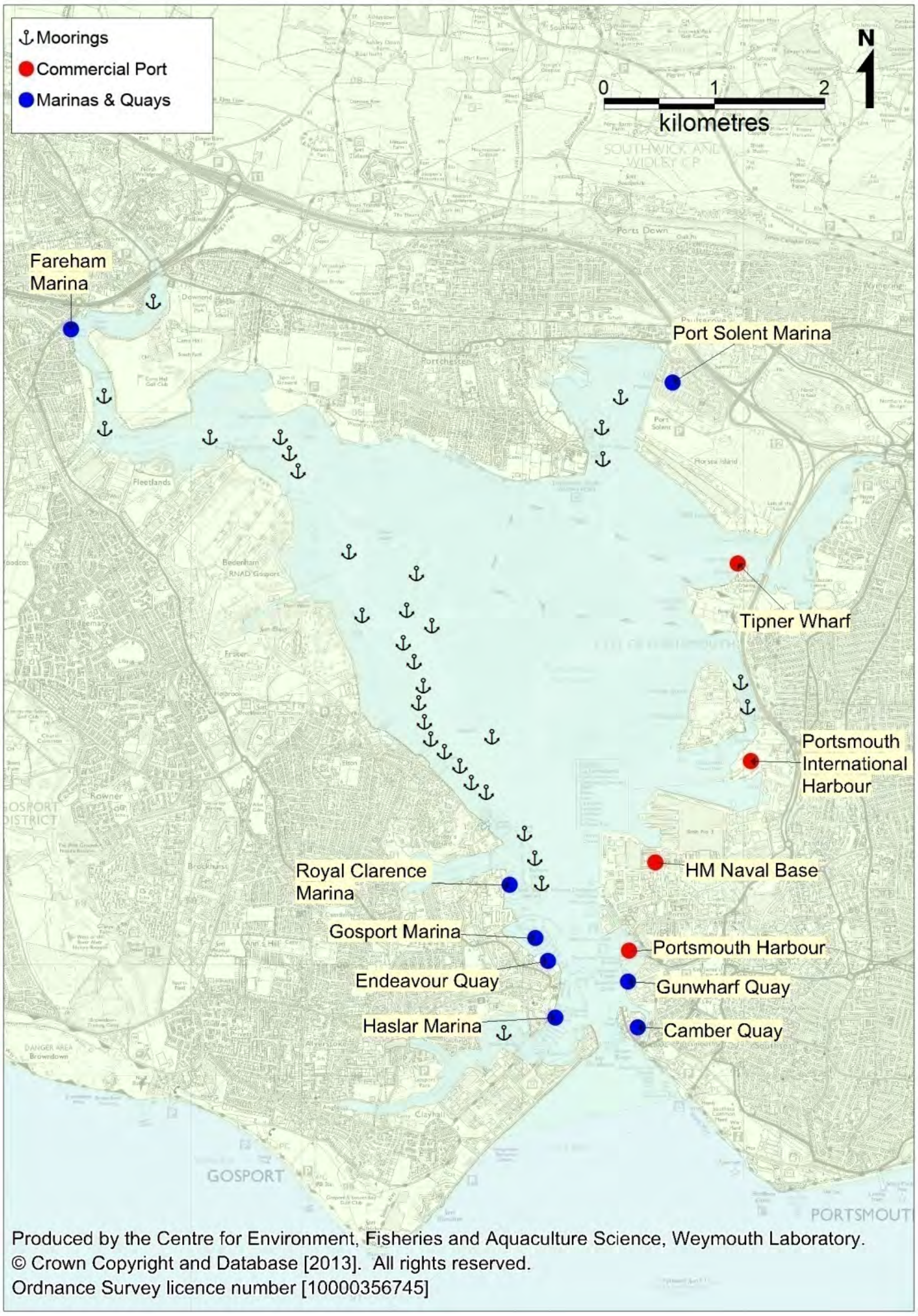

Figure IV.1: Boating activity in Portsmouth Harbour

Portsmouth International Port is a busy commercial, cruise and ferry port with around 3,000 shipping movements each year (Portsmouth City Council, 2012). The port handles a range of commodities including the importation of fresh fruit, steel, timber and vehicles and the exportation of building material, vehicles and steel. In 2012 the total imports and exports weighed 1.5 million tonnes (Portsmouth City Council, 2012). There are regular car and passenger ferry sailings to France, Spain, the Channel Islands and the Isle of Wight. In addition to this, cruise ships operate from the port, around 38 cruises were run in 2012, transporting passengers across Europe and the Mediterranean. South of the international port is an HM naval base, which is home to almost two thirds of the navy's surface ships (Royal Navy, 2013). A small passenger ferry also runs daily between Gosport and Portsmouth. Merchant shipping vessels are not permitted to make overboard discharges within 3 nautical miles of land[2] so vessels associated with the commercial port and ferry terminal should produce little or no impact. Military vessels are not required to comply with these regulations, although in practice it is likely that they generally do.

Portsmouth's commercial fishing fleet of around 20 to 30 vessels operates out of Camber Quay, close to the mouth of the harbour (Portsmouth International Port, 2013). There are 5 charter boats available for hire in Portsmouth (CBUK, 2013) and frequent boat tours run within the harbour taking visitors to see the Naval Base, museums of Portsmouth and across the Solent.

Recreational boat traffic is very heavy within Portsmouth Harbour. There are 5 marinas with berthing available for around 2,000 pleasure craft of varying size and numerous quays with pontoon space and moorings. These are mainly situated on the western edge of the estuary across from the busy international port. None of the marinas within Portsmouth Harbour contain sewage pump out facilities.

Several watersports and sailing clubs are situated around the perimeter of Portsmouth Harbour offering a variety of taster sessions, training and racing for dinghies and the larger yachts. Other watersports includes canoeing, kayaking, windsurfing and powerboating. However, the smaller recreational boats are not large enough to contain onboard toilet facilities and therefore are unlikely to make overboard discharges.

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 in the lower estuary. 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 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, therefore 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.

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

Appendix V. Sources and Variation of Microbiological Pollution: Wildlife

Portsmouth Harbour encompasses a variety of habitats including large areas of intertidal mudflats, eel grass, saltmarsh, and sand and shingle banks in the lower estuary. These features attract significant populations of birds and other wildlife. Consequently the upper reaches of Portsmouth Harbour have been designated as a Special Protection Area (SPA), a Ramsar site and a Special Site of Scientific Interest (SSSI) for its nationally and internationally populations of overwintering waterbirds.

The most significant wildlife aggregation in terms of shellfish hygiene is likely to be overwintering waterbirds (waders and wildfowl). 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). An average total count of 12,810 waterbirds (wildfowl and waders) was reported over five winters up to 2010/11 in Portsmouth Harbour (Holt et al., 2012). Species include Dark-bellied Brent Geese, Dunlin, Black-tailed Godwit and Red-breasted Merganser (Environmental Gain Ltd., 2010).

Grazing species (e.g. geese) will mainly frequent 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 any shellfish beds on the intertidal. 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. At high tide waders are likely to frequent the saltmarsh and the perimeter of the estuary. 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. There were no breeding colonies reported within or around Portsmouth Harbour during a survey of breeding seabirds in the early 2000s (Mitchell et al, 2004). Black headed gulls are however reported to be in abundance at Tipner Headland (Environmental Gain Ltd., 2010).

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. Their faeces will be carried into coastal waters via runoff from their nesting sites or via direct deposition to the adjacent intertidal.

There is a small colony of harbour seals, between 23 and 25 that live within the eastern Solent. Haul out sites are situated in both Langstone and Chichester Harbours, east of Portsmouth (The Wildlife Trusts' South East Marine Programme, 2010). Seals forage widely and therefore are likely to enter Portsmouth Harbour from time to time. Impacts are likely to be minor, and unpredictable in both spatial and temporal terms. Due to their low numbers and high mobility the presence of seals will not influence the sampling plan.

Appendix VI. Meteorological Data: Rainfall

The Eastney weather station received an average of 654 mm per year between 2003 and 2012. Figure VI.1 presents a boxplot of daily rainfall records by month at Eastney.

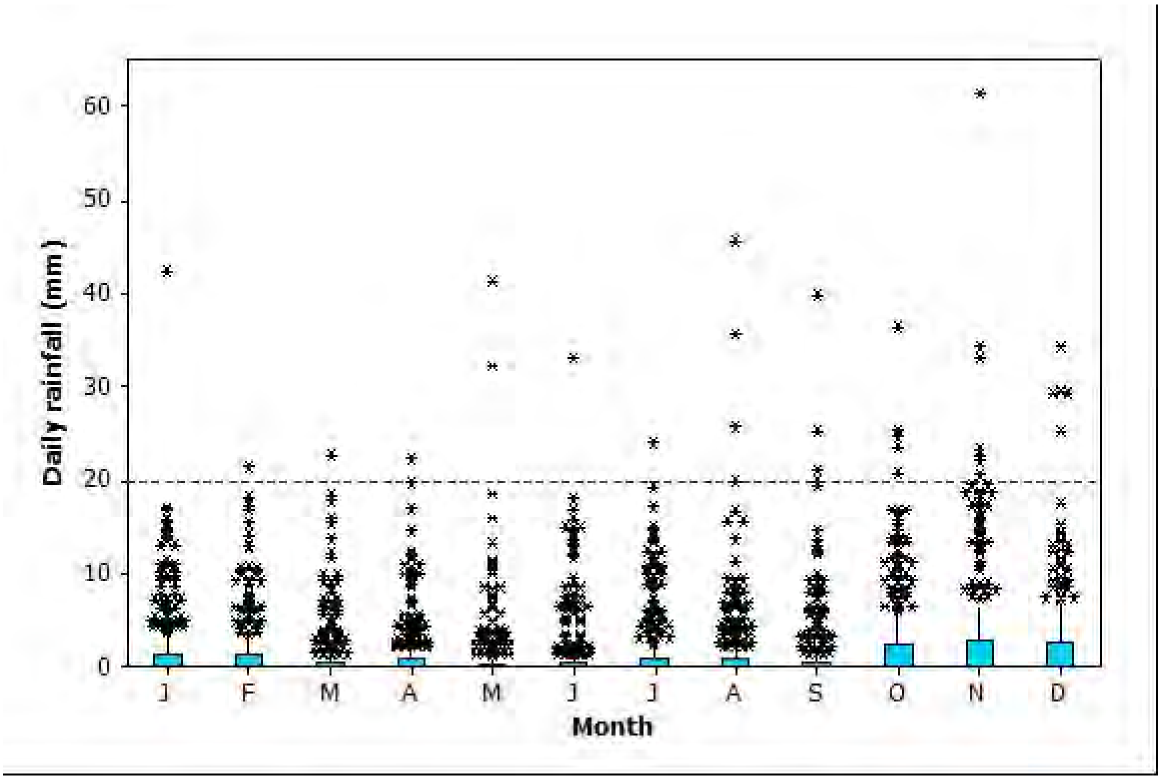

Figure VI.1: Boxplot of daily rainfall totals at Eastney, January 2003 to December 2012.
Data from the Environment Agency

Rainfall records from Eastney, which is representative of conditions in the vicinity of Portsmouth Harbour, indicate relatively low seasonal variation in average rainfall. Rainfall was lowest on average in May and March and highest on average from October to December. Daily totals of over 20mm were recorded on 0.8% of days and 58% of days were dry. High rainfall days (>20mm) occurred in all months, but were slightly 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. 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).

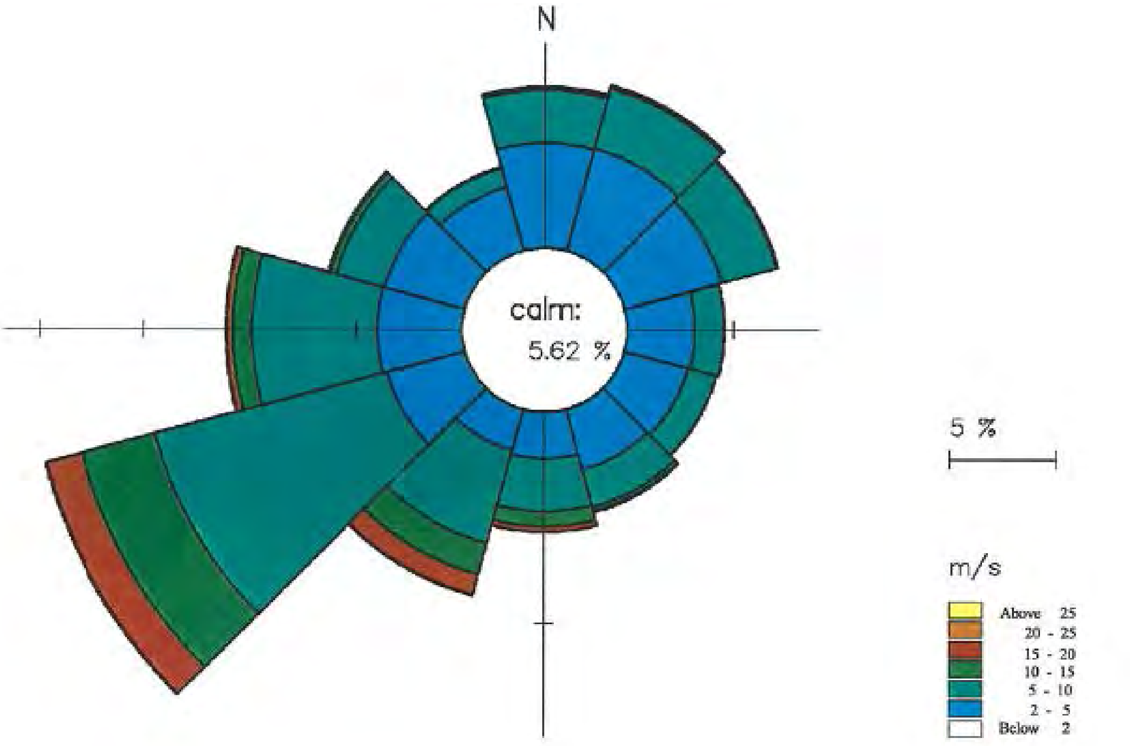

Figure VII.1: Wind Rose for Southampton Water Produced by ABPmer, 2007.

The prevailing wind direction is from the south west and the strongest winds usually blow from this direction (Figure VII.1). A higher frequency of north easterly winds occurs during spring. Coastal locations may receive onshore sea breezes between the late spring and summer months (Met Office, 2012). Portsmouth Harbour is largely enclosed, with a narrow mouth that faces south/south east and therefore receives some shelter from the prevailing winds, although the surrounding land is relatively low lying.

Appendix VIII. Hydrometric Data: Freshwater Inputs

Portsmouth Harbour has a hydrological catchment of about 159 km². The main freshwater input is Wallington River which discharges in the north-west corner of the estuary via Fareham Lake (Figure VIII.1). The Wallington River flows predominantly through rural land in its upper reaches, and urbanised land in the lower catchment. Aside from the Wallington, there are only two small watercourses shown on Figure 5.8, both of which discharge to the Fareham Lake.

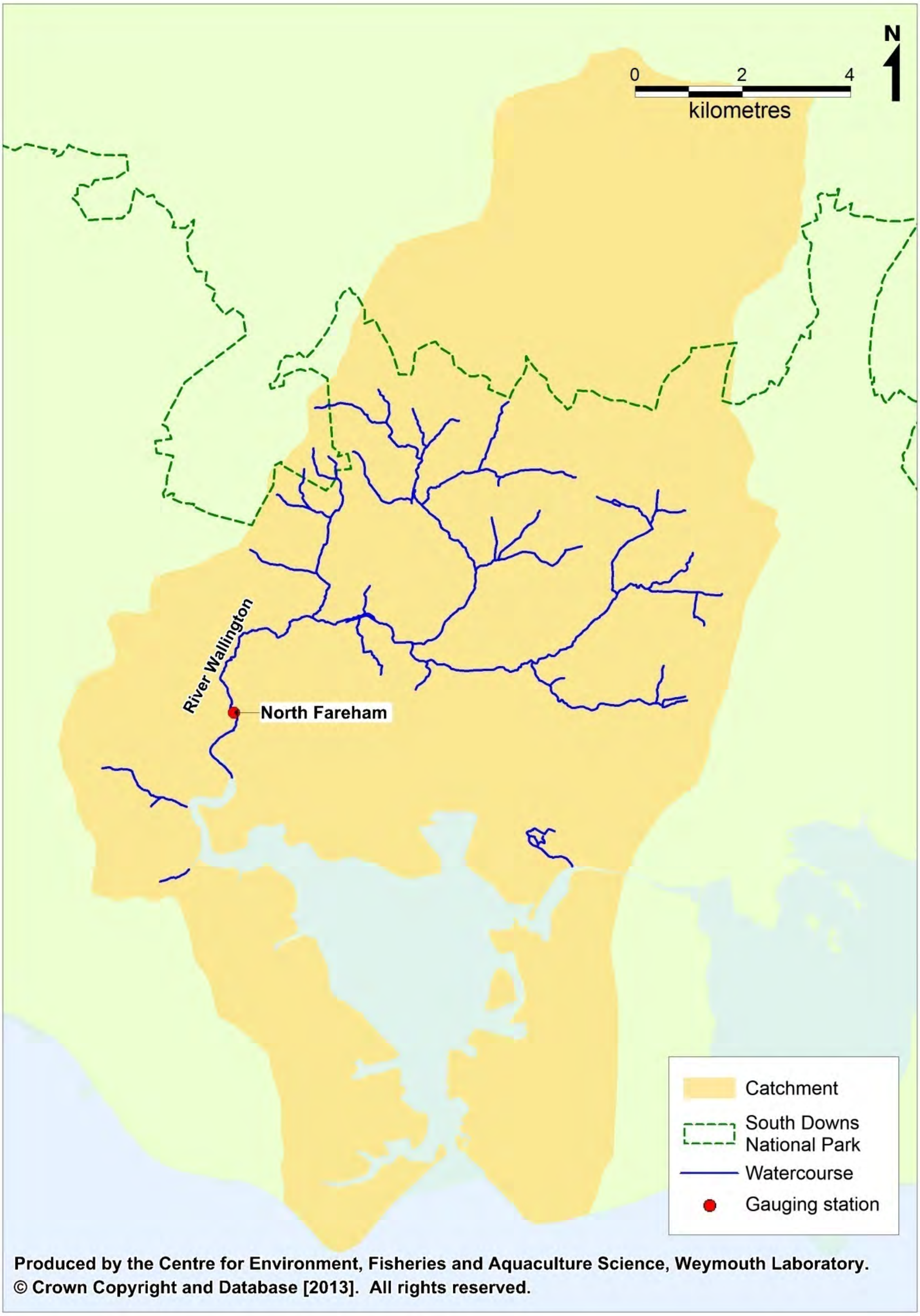

Figure VIII.1: Freshwater inputs into Portsmouth Harbour

The northern reaches of the catchment are underlain by the chalk of the South Downs, where rainfall permeates the land and travels through aquifers rather than travelling across the surface via watercourses. The flow of groundwater through aquifers is typically very slow, from 1 m/year to 1 m/day (Environment Agency, 2011). Such lengthy travel times suggest little microbial contamination would survive passage given that 50 days are deemed sufficient to remove microbial contamination from groundwater flows. It is therefore highly unlikely that microbiological contamination originating from aquifers poses any threat to the shellfish beds in Portsmouth Harbour. The lower catchment is characterised by a more impermeable geology, with horizontal bands of Reading and London Clay, Bagshot Sands and Bracklesham Sands (West, 2007). This division in geology between the upper and lower catchments causes groundwater to re-emerge via springs and for watercourses to flow across the surface.

The river will receive microbiological pollution from point and diffuse sources such as STW discharges and urban and agricultural runoff. It is therefore a potentially significant source of microbiological contamination for shellfisheries within the harbour. Summary statistics for a flow gauge on the River Wallington is presented in Table VIII.1 for the period 2003 to 2013.

Table VIII.1: Summary flow statistics for North Fareham flow gauge station on the River Wallingford draining into Portsmouth,

Station name	Catchment (km^2)	Mean Flow (m^3s^{-1})	Q95[1] (m^3s^{-1})	Q10[2] (m^3s^{-1})
North Fareham	111	0.588	0.032	1.347

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

Data from the Environment Agency and Centre for Ecology and Hydrology

The Wallington River has low mean flow rates of 0.588 m^3s^{-1}. A boxplot of mean daily flow by month at the North Fareham gauging station is presented in Figure VIII.2.

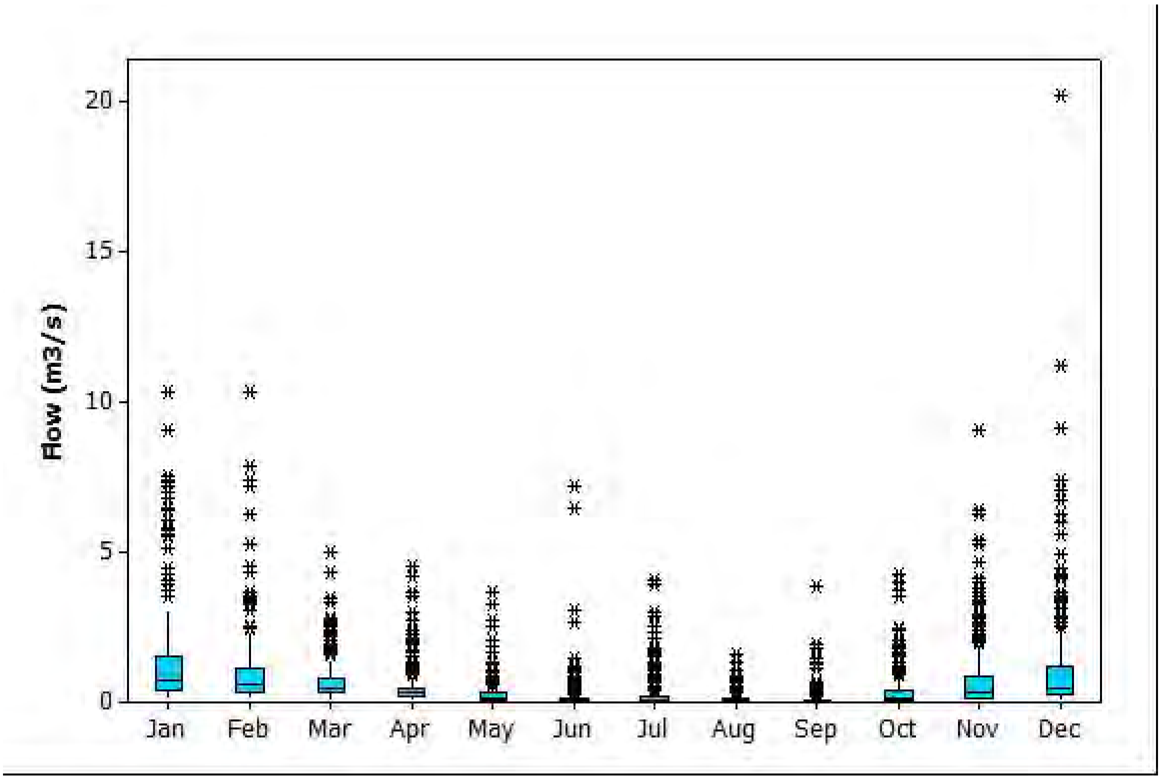

Figure VIII.2: Boxplots of mean daily flow records from North Fareham gauging station on the River Wallington from 2003 - 2013

A strong seasonality in discharge is apparent. Flows were considerably higher on average during the colder months of the year, with peak flow events generally occurring from November to February. During the warmer months, flows were around base flow for much of the time, with sporadic elevated flow events.

The seasonal pattern of flows is not entirely dependent on rainfall as during the colder months there is less evaporation and transpiration, leading to a higher water table. This 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.

A large number of pipes and small outfalls (around 100) associated with the drainage of built up areas were observed. The majority were not discharging at the time of survey, which was undertaken during a hot, dry period. These surface water outfalls represent widely distributed, small and often intermittent sources of urban runoff. The volumes of runoff and the bacterial loadings they carry into the harbour will fluctuate greatly in response to rainfall.

Appendix IX. Hydrography

IX.1. Bathymetry

Portsmouth Harbour is a partially enclosed tidal inlet which faces south and drains into the eastern Solent. It covers an area of about 16 km^3, of which 60% is intertidal mudflats and saltmarsh (Futurecoast, 2002). Consequently a large proportion of water will be exchanged on each tide, but the dilution potential will be quite low away from the main channels.

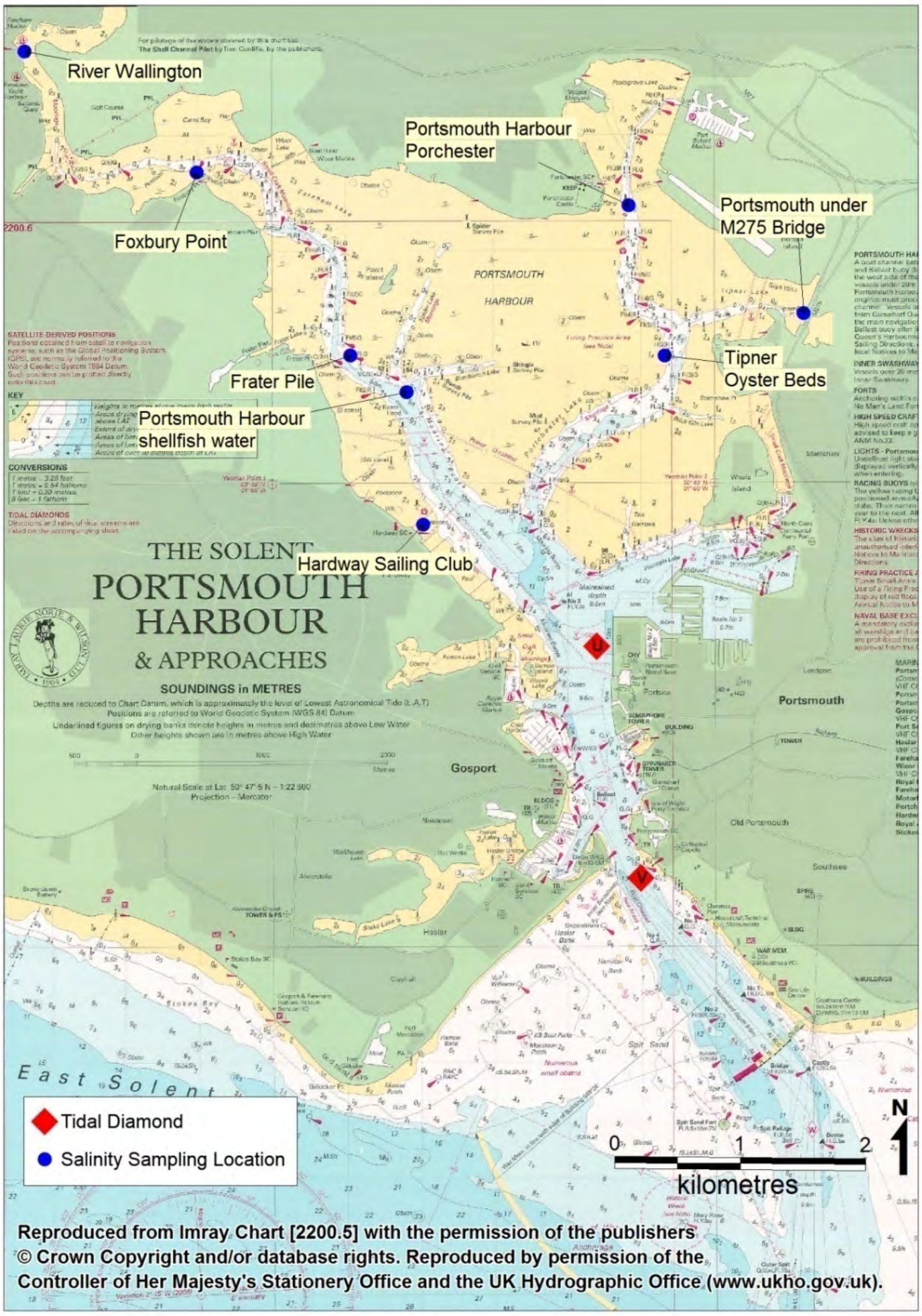

Figure IX.1: Bathymetry of Portsmouth Harbour

It has a narrow, constricted mouth with a maximum depth of 13m below Chart Datum. Inside the mouth it then widens significantly and the main channel splits into a further two channels in the upper estuary which head north west (Fareham Channel) and north east (Portchester Channel). There is a connection from the north east harbour to neighbouring Langstone Harbour (Ports Creek) which dries at low water and is as narrow as 20m in width in places.

There is a clear division between the upper and lower estuary. The upper estuary which consists of clays and silts is much shallower with depths of around 1 to 3m below CD and is largely intertidal. The lower estuary comprises mainly of gravels and sands and has a depth of around 8.5m and 9.5m below CD. This depth is maintained in the main navigational channels. The change in seabed sediments suggests there is a change in tidal stream strengths, with smaller particle sizes in the upper estuary suggesting lower current velocities (Lavender, 2010).

The majority of the perimeter of the harbour is protected by walls, revetments or gabions preventing flooding to coastal areas. Reclaimed land is present in the south east of the harbour, upon which the Naval Dockyards, military establishments, commercial ports and ferry terminals have been built.

IX.2. Tides and Currents

Currents in coastal waters are predominantly driven by a combination of tide, wind and freshwater inputs. Portsmouth Harbour is macro-tidal and expresses a semi diurnal cycle with an average tidal range on spring tides of 3.9m on spring tides and 3.0m on neap tides. Tides are asymmetrical, with a shorter duration and faster moving ebb tide (ebb dominant).

Table IX.1: Tide levels and ranges within Portsmouth Harbour

	Height above chart datum (m)				Range (m)	
Port	**MHWS**	**MHWN**	**MLWN**	**MLWS**	**Spring**	**Neap**
Portsmouth	4.7	3.8	1.9	0.8	3.9	1.9

Data from Admiralty TotalTide

Advection of pollutants by tidal currents is likely to be the main mode of contaminant transport and dispersal. In the Solent tidal streams flood parallel to the coast in an easterly direction, so the Harbour therefore fills with water moving along the Solent shore from the west. Any major sources discharging to this stretch of coast may add to levels of contamination within Portsmouth Harbour. The ebb tide will carry contamination from shoreline sources out through the estuary.

There are two tidal diamonds within Portsmouth Harbour. Station V is located in the mouth of Portsmouth and Station U is located further north, to the west of the Naval Dockyards.

Table IX.2: Tidal stream predictions for Portsmouth Harbour

Time before /after High Water	Station V			Time before /after High Water	Station U		
	Direction (°)	Rate (m/s) Spring	Rate (m/s) Neap		Direction (°)	Rate (m/s) Spring	Rate (m/s) Neap
HW-6	336	0.62	0.15	HW-6	50	0.05	0.05
HW-5	341	0.46	0.15	HW-5	14	0.00	0.05
HW-4	336	0.21	0.26	HW-4	337	0.00	0.10
HW-3	338	0.77	0.51	HW-3	340	0.21	0.21
HW-2	343	1.44	0.67	HW-2	346	0.57	0.26
HW-1	342	1.44	0.62	HW-1	349	0.77	0.26
HW	329	0.21	0.10	HW	344	0.26	0.15
HW+1	165	0.46	0.26	HW+1	187	0.15	0.10
HW+2	164	0.82	0.77	HW+2	174	0.26	0.26
HW+3	159	2.11	0.98	HW+3	167	0.77	0.41
HW+4	155	1.54	0.51	HW+4	154	0.46	0.26
HW+5	161	0.46	0.10	HW+5	175	0.15	0.10
HW+6	334	0.46	0.15	HW+6	78	0.05	0.05
Excursion (flood)		20 km	9 km	Excursion (flood)		7 km	4 km
Excursion (ebb)		19 km	9 km	Excursion (ebb)		7 km	4 km

Data from Imray Chart 2200.5 (The Solent Portsmouth Harbour and Approaches)

Both tidal diamonds confirm that tidal streams move into the harbour and up the channels on the flood, with the reverse occurring on the ebb (Table IX.2). The strongest tidal flows are experienced at Station V, in the harbour entrance, peaking at 2.11m/s on an ebb spring tide. The strongest current at Station U, also on an ebb spring tide is less than half that at station V (0.77 m/s). Tidal diamond U, closest to the fishery indicates that the tidal excursion (the distance water travels during the course of a flood or ebb tide) is in the approximate order of 7km on spring tides and 4km on neap tides suggesting that sources discharging to the inner reaches of the harbour could be flushed out of the estuary on an ebb tide. However, current velocity and subsequently the tidal excursion are expected to decrease significantly in the inner reaches of the harbour, particularly over the intertidal areas.

On the flood tide the main tidal streams flow in a northerly direction up the main subtidal channels. As these channels fill, the tidal flow will progress up intertidal creeks and spread over the mudflats. The reverse will occur on the ebb. At higher states of the tide, contamination from shoreline sources will tend to impact to either side, becoming progressively more diluted. Around low water, contamination from shoreline sources such as surface water outfalls will be carried via channels cut across the intertidal area. At such times, these channels may carry relatively high concentrations of indicator bacteria.

Although the vast majority of water exchange is via the harbour mouth, there is some limited exchange with Langstone Harbour via Ports Creek. This exchange is in a net westerly direction, so it is possible that contamination from any sources discharging to this channel and the north western corner of Langstone Harbour may be an influence. The volumes of water involved are relatively minor, at around 1.5% of the tidal prism for Langstone Harbour (Portsmouth Polytechnic, 1976).

Superimposed on tidally driven currents are the effects of freshwater inputs and wind. The main freshwater input discharges to the head of the Fareham Creek. The flow ratio (freshwater input:tidal exchange) is very low and the system is well mixed overall, so density effects are unlikely to significantly modify tidal circulation.

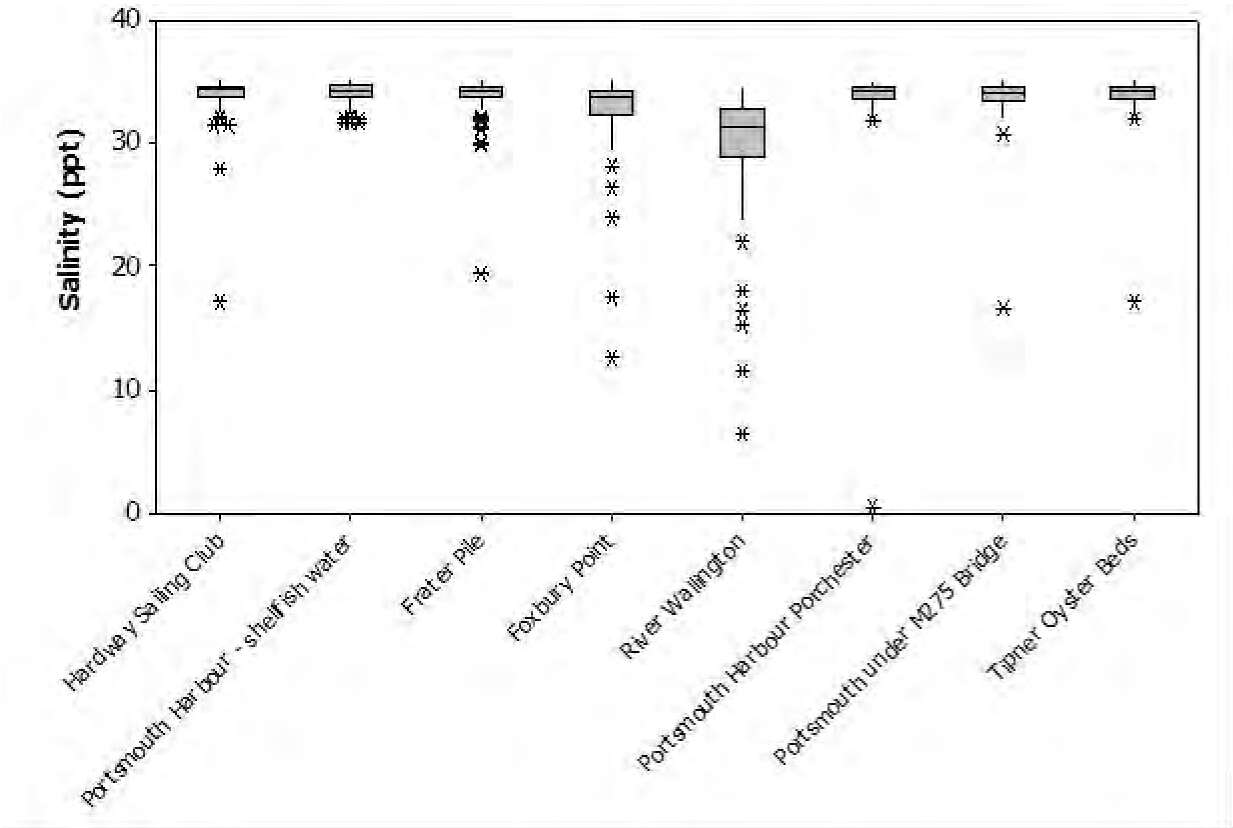

Figure IX.2: Boxplot of salinity readings taken in Portsmouth Harbour 2003 - 2013
Data from the Environment Agency

Salinity measurements taken between 2003 and 2013 at eight points within Portsmouth Harbour indicate that average salinities are approaching that of full strength seawater throughout. Some lower salinities were recorded, mainly at the two sites in the Fareham channel (River Wallington and Foxbury Point). This channel receives the main freshwater input at its head, and the decreased salinity is likely to be associated with increased levels of runoff borne contamination here.

Strong winds will modify surface currents. Winds typically drive surface water at about 3% of the wind speed (Brown, 1991) so gale force wind (34 knots or 17.2 m/s) would drive a surface water 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 number 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 Portsmouth Harbour strong wave action is not anticipated.

Appendix X. Microbiological Data: Seawater

There is one shellfish waters site designated under Directive 2006/113/EC (European Communities, 2006) in Portsmouth Harbour. Figure X.1 shows the location of this site. Table X.1 presents summary statistics for bacteriological monitoring results and Figure X.2 presents a boxplot of these results.

Figure X.1: Location of monitoring point in Portsmouth Harbour
Data from the Environment Agency

Table X.1: Summary statistics for shellfish waters faecal coliform results, 2003 to 2013 (cfu/100ml).

Site	Portsmouth Harbour
No.	43
Date of first sample	07/01/2003
Date of last sample	11/04/2013
Geometric mean	15.0
Min.	1
Max.	577
% over 100	20.9
% over 1000	0.0

Data from the Environment Agency

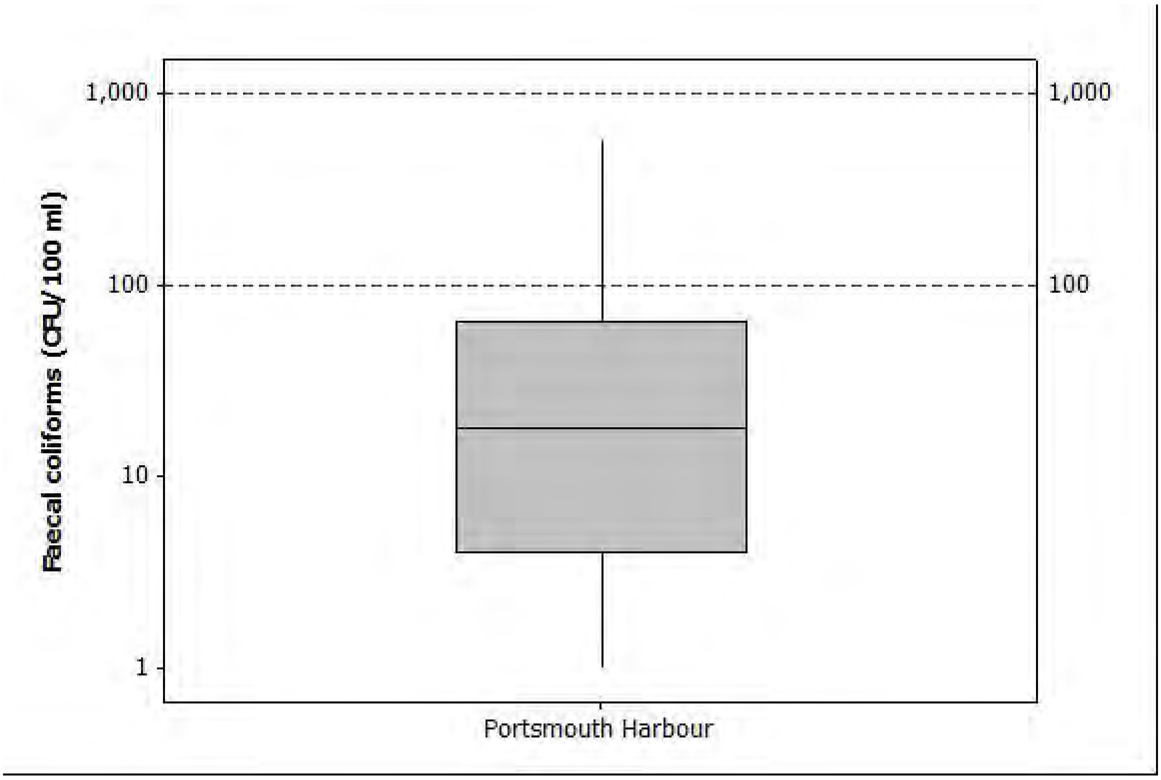

Figure X.2: Box-and-whisker plots of all faecal coliforms results
Data from the Environment Agency

Levels of faecal indicator bacteria within Portsmouth Harbour were moderate, with no particularly high results recorded, although they did exceed 100 faecal coliforms/100ml for about 20% of the time.

X.1. Overall temporal pattern in results

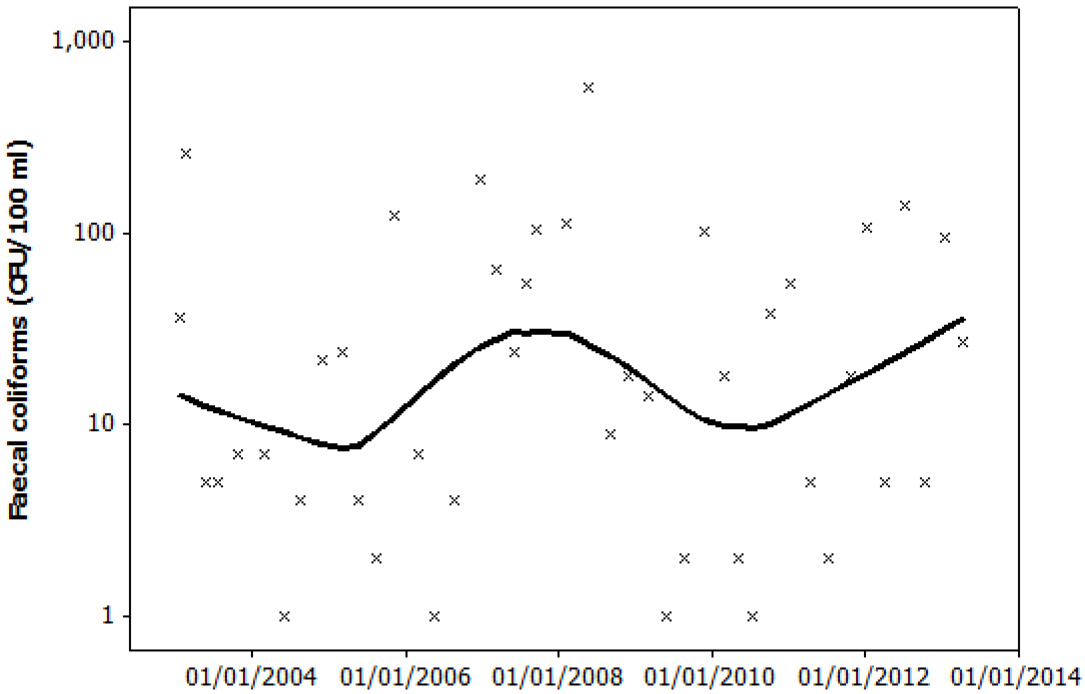

Figure X.3: Scatterplot of faecal coliform results by date, overlaid with lowess lines
Data from the Environment Agency

Figure X.3 shows that faecal coliform levels have fluctuated between 2003 and 2013. In 2005, levels were at their lowest, but then increased again until late 2007, when they decreased until 2010. Since 2010 faecal coliform levels have been increasing on average.

X.2. Seasonal patterns of results

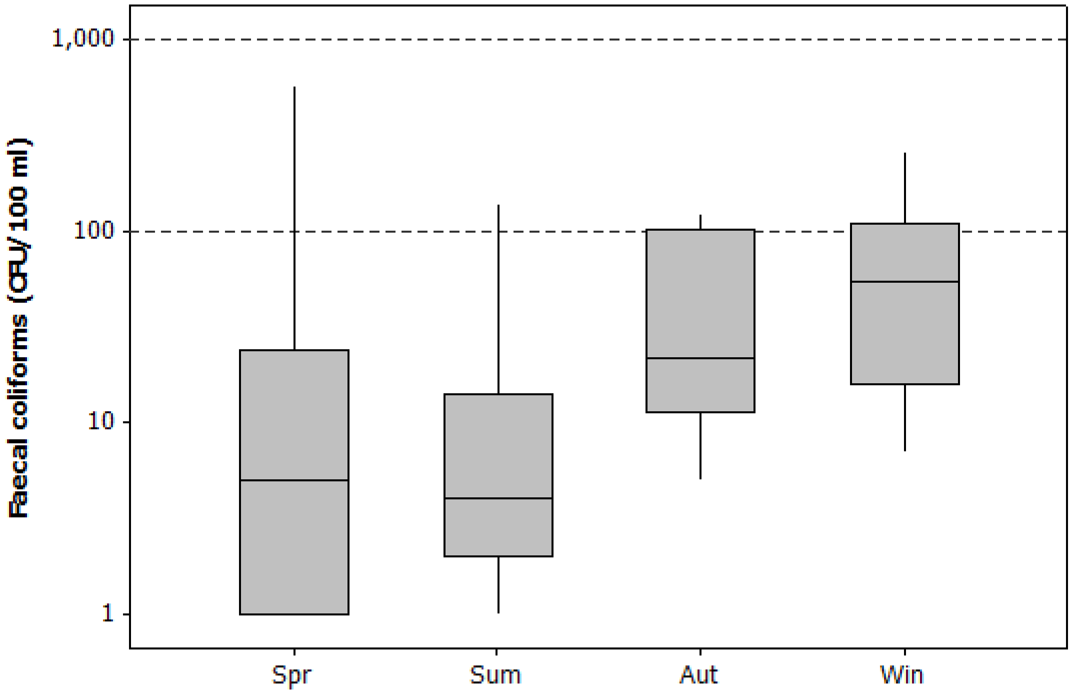

Figure X.4: Boxplot of faecal coliform results by site and season
Data from the Environment Agency

Comparisons (One-way ANOVA) of faecal coliform levels revealed that there was a significant difference between seasons (p=0.003). Post ANOVA Tukey tests showed that faecal coliform levels were significantly higher during the winter than during the spring and summer.

X.3. Influence of tide

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

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

High/low tides		Spring/neap tides	
r	p	r	p
0.243	0.094	0.111	0.612

Data from the Environment Agency

No significant (p<0.05) correlations were found between faecal coliform levels and tidal state.

X.4. Influence of rainfall

To investigate the effects of rainfall on levels of contamination at the water quality monitoring sites Spearman's rank correlations were carried out between rainfall recorded at the Eastney weather station (Appendix II for details) over various periods running up to sample collection and faecal coliform results. These are presented in Table X.3 and statistically significant correlations ($p<0.05$) are highlighted in yellow.

Table X.3: Spearmans Rank correlation coefficients for faecal coliform results against recent rainfall

n		41
24 hour periods prior to sampling	1 day	0.529
	2 days	0.373
	3 days	0.379
	4 days	0.247
	5 days	0.139
	6 days	0.262
	7 days	0.278
Total prior to sampling over	2 days	0.549
	3 days	0.656
	4 days	0.566
	5 days	0.513
	6 days	0.465
	7 days	0.423

Data from the Environment Agency

Faecal coliform levels were rapidly affected by rainfall events, with the strongest influence arising one day after a rainfall event, perhaps due to runoff from the bordering urban areas. There is also a weaker more delayed influence which may be due to runoff from the larger River Wallington catchment.

X.5. Influence of salinity

Salinity measurements were taken at the time of bacteriological sampling. Figure X.5 presents a scatterplot showing the relationship between salinity and faecal coliform concentrations.

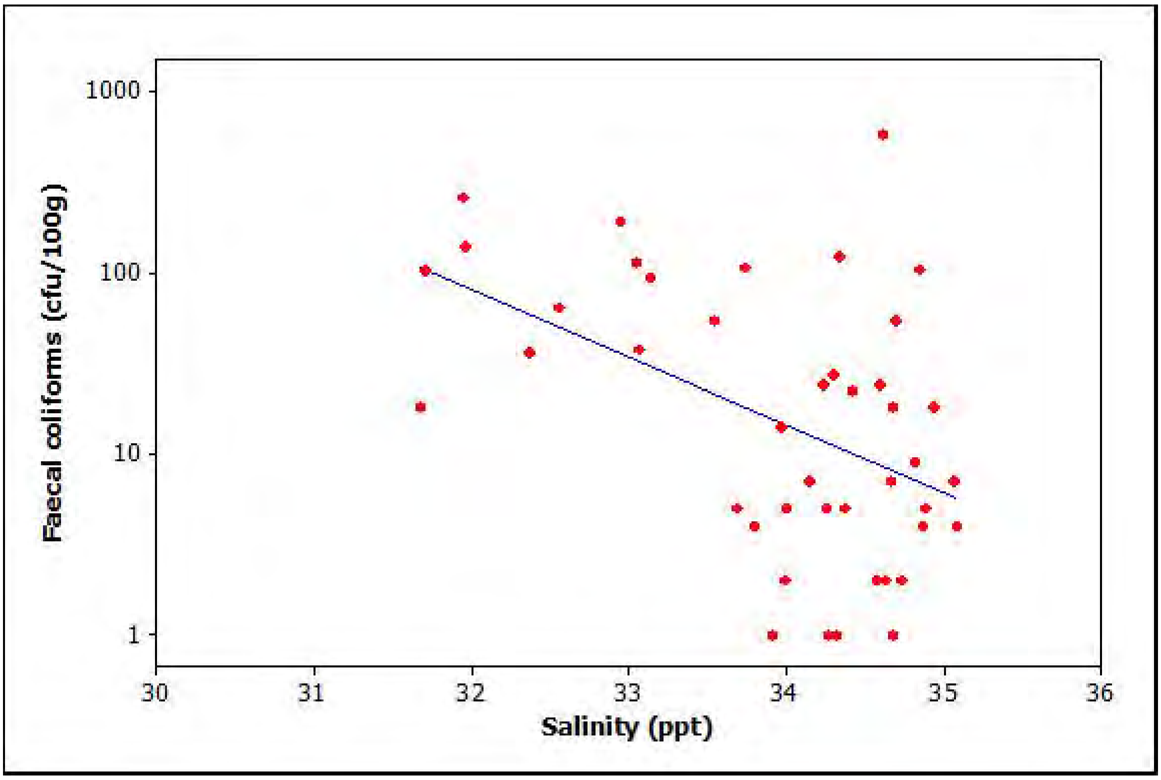

Figure X.5: Scatterplot of faecal coliform results against salinity
Data from the Environment Agency

Although salinity did not vary greatly, fewer low results were recorded when salinity dropped below 34ppt. A significant negative correlation was found between the two parameters (Pearsons correlation, r=-0.479, p=0.001).

Appendix XI. Microbiological Data: Shellfish Flesh

XI.1. Summary statistics and geographical variation

There are a total of 3 RMPs in the Portsmouth Harbour that have been sampled between 2003 and 2013. The geometric mean results of shellfish flesh monitoring from all RMPs sampled from 2003 onwards are presented in Figure XI.1. Summary statistics are presented in Table XI.1 and boxplots for sites are show in Figure XI.2.

Figure XI.1: Bivalve RMPs active since 2003

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

RMP	Species	No.	Date of first sample	Date of last sample	Geometric mean	Min.	Max.	% over 230	% over 4600	% over 46000
Post 50	Native oyster	25	09/05/2011	16/05/2013	677.6	130	5400	96.0	8.0	0.0
Peewit Island	Native oyster	99	07/01/2003	04/04/2011	596.8	<20	54000	77.8	7.1	1.0
Portchester Lake	Native oyster	123	07/01/2003	16/05/2013	572.0	40	16000	82.1	2.4	0.0

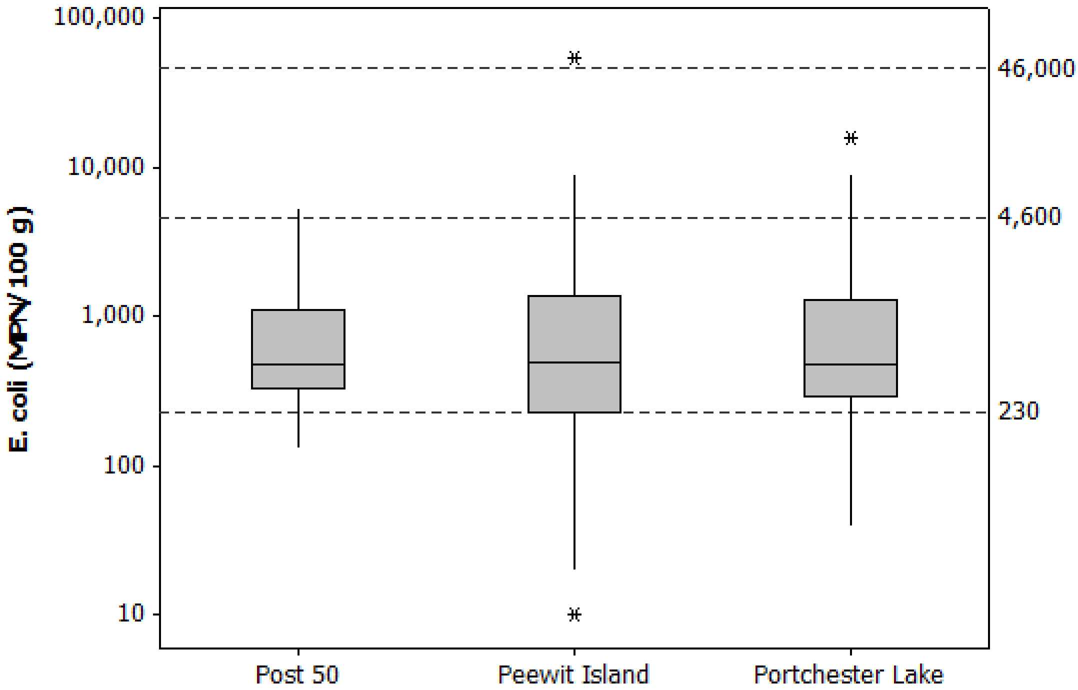

Figure XI.2: Boxplots of *E. coli* results from native oyster RMPs from 2003 onwards.

Peewit Island was only sampled up until April 2011, and Post 50 was only sampled from May 2011, so some caution should be exercised when comparing results from these two sites.

The geometric mean *E. coli* result was very similar at all three RMPs, with no significant difference between them (one-way ANOVA, p=0.818). A lower proportion of results exceeded 4,600 MPN/100g at Portchester Lake compared to the two RMPs in the west channel. One prohibited level result was recorded at Peewit Island.

Comparisons of paired (same day) samples taken from Portchester Lake and the other two RMPs revealed significant correlations on a sample by sample basis in both cases. Neither were particularly strong correlations, and the correlation between Peewit Island and Portchester Lake (Pearsons correlation, r=0.262, p=0.009) was slightly stronger than that between Post 50 and Portchester Lake (Pearsons correlation, r=0.408, p=0.038). This suggests that the two channels are influenced by broadly similar sources.

XI.2. Overall temporal pattern in results

The overall variation in *E. coli* levels found in bivalves is shown in Figure XI.3.

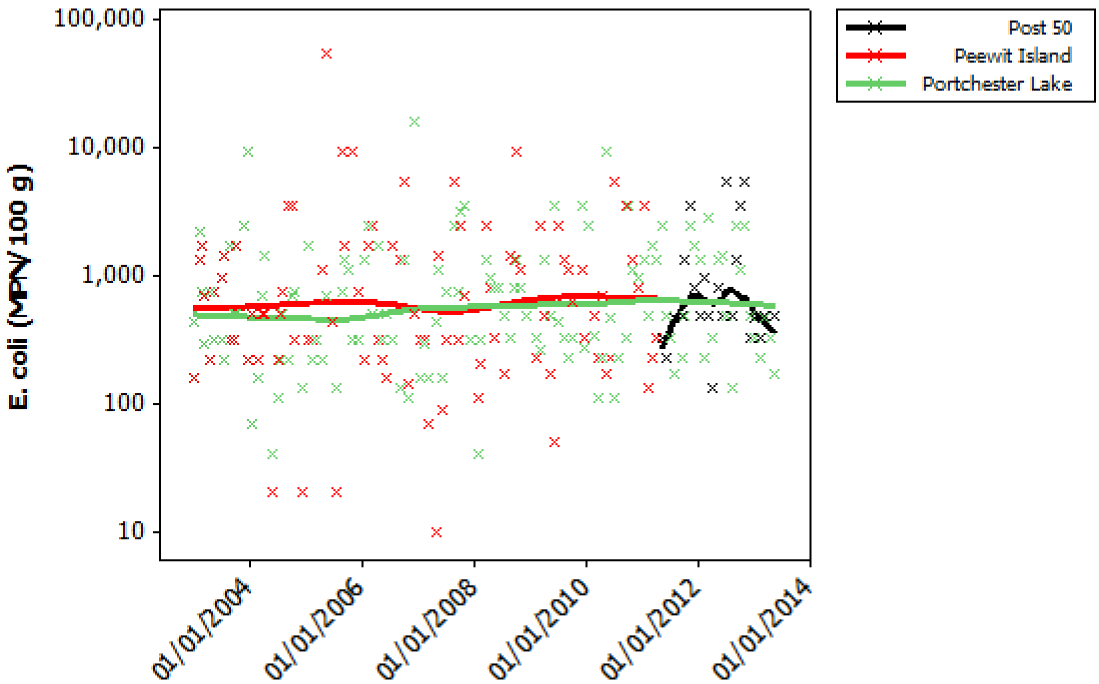

Figure XI.3: Scatterplot of *E. coli* results by sample date, overlaid with lowess lines.

The level of *E. coli* in native oysters has remained stable at Peewit Island and Portchester Lake since 2003.

XI.3. Seasonal patterns of results

The seasonal patterns of results from 2003 to 2013 were investigated by RMP.

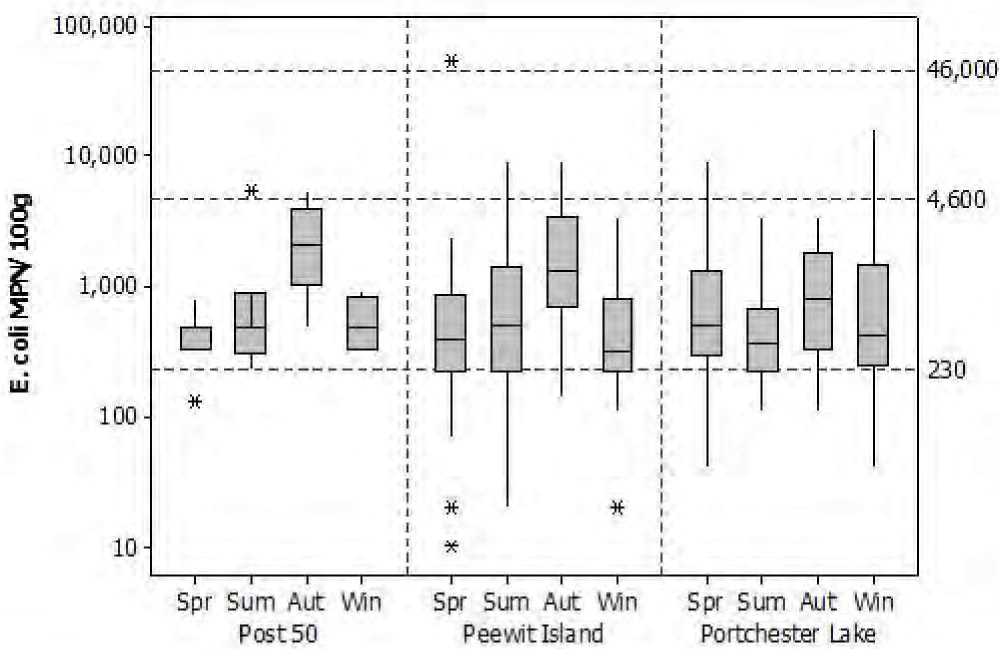

Figure XI.4: Boxplot of *E. coli* results by RMP and season

One-way ANOVA tests showed that there were significant seasonal variations at Post 50 and Peewit Island ($p=0.009$ and 0.005 respectively), but not at Portchester Lake ($p=0.175$). Post ANOVA tests showed that there were significantly higher levels of *E. coli* during the autumn than winter and spring at Post 50 and Peewit Island. This suggests that sources of differing seasonality are influencing the east and west channels.

XI.4. Influence of tide

To investigate the effects of tidal state on *E. coli* results, circular-linear correlations were carried out against the high/low and spring/neap tidal cycles for each RMP where more than 30 samples had been taken. Results of these correlations are summarised in Table XI.2, and significant results are 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 tides		Spring/neap tides	
Site Name	**r**	**p**	**r**	**p**
Peewit Island	0.071	0.620	0.181	0.043
Portchester Lake	0.235	0.001	0.078	0.484

Data from the Environment Agency

Figure XI.5 presents a polar plot of $\log_{10}$ *E. coli* results against tidal state on the high/low cycle for Portchester Lake, where a significant correlation was detected. High water at Portsmouth is at 0° and low water is at 180°. Results of 230 *E. coli* MPN/100g or less are plotted in green, those from 231 to 4600 are plotted in yellow, and those exceeding 4600 are plotted in red.

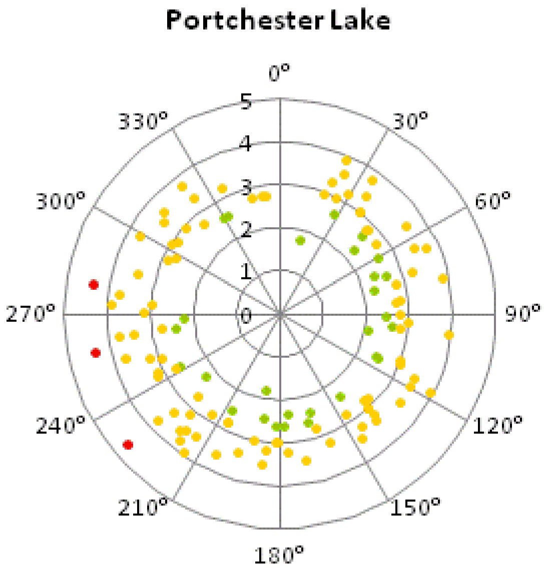

Figure XI.5: Polar plot of $\log_{10}$ E. coli results (MPN/100g) against high/low tidal state

Figure XI.5 tentatively suggests a slight tendency for higher levels of *E. coli* during the flood tide.

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

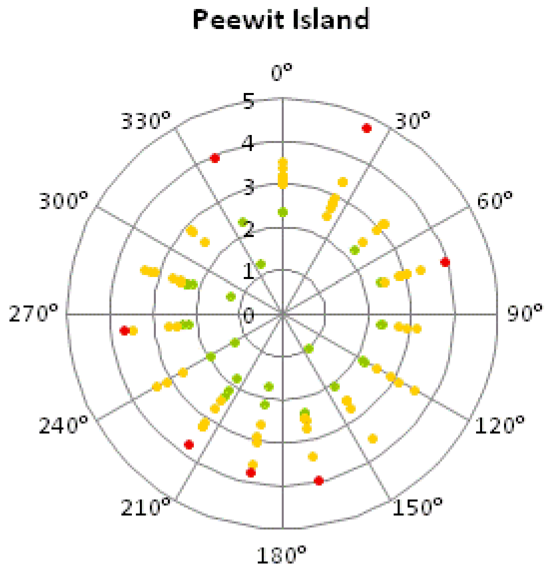

Figure XI.6: Polar plot of $\log_{10}$ *E. coli* results (MPN/100g) against spring/neap tidal state

At Peewit Island, fewer low results arose during the larger, spring tides, although the overall pattern was not particularly strong.

XI.5. 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 Eastney weather station (Appendix II 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 Eastney and shellfish hygiene results

Site		**Post 50**	**Peewit Island**	**Portchester Lake**
Species		**Native oyster**	**Native oyster**	**Native oyster**
n		**20**	**99**	**118**
24 hour periods prior to sampling	1 day	0.271	0.179	0.119
	2 days	-0.016	0.294	0.304
	3 days	0.114	0.268	0.274
	4 days	-0.013	0.167	0.075
	5 days	0.532	0.210	0.141
	6 days	0.615	0.024	0.281
	7 days	0.183	0.069	0.102
Total prior to sampling over	2 days	0.167	0.241	0.305
	3 days	0.089	0.257	0.382
	4 days	0.031	0.297	0.334
	5 days	0.225	0.312	0.310
	6 days	0.263	0.299	0.352
	7 days	0.322	0.308	0.341

Levels of *E. coli* were influenced by rainfall very rapidly at Peewit Island and continued to be affected for several days. Portchester Lake oysters were also affected by rainfall but not as quickly as at Peewit Island. Little influence of rainfall was seen at Post 50 and the response was delayed, but it must be noted that much fewer samples were taken from here.

Appendix XII. Shoreline Survey Report

Date (time):

10th July 2013 (0700-15:30)

11th July 2013 (0715-12:30)

Cefas Officers:

Simon Kershaw, Rachel Parks & David Walker

Local Enforcement Authority Officers:

Steve Lucking (Portsmouth City Council, Port Health Authority)

Area surveyed:

Perimeter of Portsmouth Harbour (Figure XII.1, by boat and Figure XII.2, by foot).

Weather:

10th July 2013, sunny, 27°C, wind ESE force 1-2 gusting 4.

11th July 2013, overcast, 23°C, wind W force 3.

Tides:

Admiralty TotalTide predictions for Portsmouth Harbour (50°47'N 1°06'W). All times in this report are BST.

10/07/2013			**11/07/2013**		
High	01:22	4.5 m	High	01:54	4.4 m
High	13:53	4.5 m	High	14:26	4.5 m
Low	06:43	1.0 m	Low	07:15	1.0 m
Low	19:00	1.2 m	Low	19:31	1.2 m

XII.1. Objectives:

The shoreline survey aims to obtain samples of freshwater inputs to the area for bacteriological testing; confirm the location of previously identified sources of potential contamination; locate other potential sources of contamination that were previously unknown and find out more information about the fishery. A full list of recorded observations is presented in Table XII.1 and Table XII.2 and the locations of these observations are mapped in Figure XII.1 and Figure XII.2. Photographs are presented in Figure 5.29-Figure 5.56. The shoreline survey was undertaken over two days by both boat and by foot. Every effort was made to ensure the entire shoreline was surveyed, although there were some short stretches where the shoreline could not be accessed.

XII.2. Description of Fishery

No further information was obtained on the nature of the fishery within the harbour. Shells of cockles and Manila clams were observed in places (e.g. observations 125 and 129). Individuals were seen gathering on the intertidal (observation 89) but whether they were gathering angling bait or shellfish for consumption in uncertain.

XII.3. Sources of contamination

Sewage discharges

Thirteen intermittent water company discharges were confirmed around the perimeter of Portsmouth Harbour (observation 14, 23, 26, 61,124, 130, 139, 152, 160, 163, 174, 185 & 191) see Table XII.1 and Table XII.2. The majority were not discharging; however samples were taken from observation points 23, 124 and 139.

Two surface water drainage pipes appeared to regularly carry a sewage input, with sewage fungus and pink and grey mould surrounding the entrance to the pipe (observations 132 and 172).

Two private discharges were observed on the shoreline survey. A submerged blue pipe was seen in the eastern outer mouth; it is presumed to serve the Children’s Corner discharge (observation 121) and one was sighted on the northern shore adjacent to a private mooring associated with the house behind (observation 167). A strong sulphur smell was recorded at this point. The discharge here was not flowing and therefore a sample could not be taken.

Freshwater inputs

No significant freshwater inputs were observed on the survey. A small stream was observed in the north east in Heavy Reach (observation 181); a golf course was situated behind. One main freshwater input, the River Wallington discharges to the north west of the harbour at Fareham. This was not sampled at the time of the pedestrian survey, as the intended sampling point (under the Delme Roundabout viaduct) could not be accessed.

A large number of pipes and small outfalls (around 100) associated with the drainage of built up areas were observed. The majority were not discharging at the time of survey, which was undertaken during a hot, dry period. These surface water outfalls represent widely distributed, small and generally intermittent or highly variable sources of urban runoff.

Boats and Shipping

Heavy boat traffic was observed during the survey particularly in the lower reaches close to the main commercial ports. Boats observed during the survey include ferries (both large and small), recreational boats, fishing boats, commercial shipping vessels and naval vessels. Numerous marinas and sailing clubs were observed in the Harbour.

A few houseboats where observed in two locations in the west of the Harbour (observation 50 & 85). These may make regular discharges when in occupation.

Livestock

No livestock was observed around the perimeter of Portsmouth Harbour.

Wildlife

A large aggregation of gulls (over 200) was observed on several occasions north of the harbour mouth (observation 36) and smaller aggregations of mixed species were observed on the mudflats and seawalls (observations 7, 30, 40, 80 & 105).

Dog walking and dog excrement was frequently observed along shoreline footpaths surrounding Portsmouth Harbour. Dog waste bins were observed at regular intervals along the Pilgrims Trail footpath in the north east (observation 115).

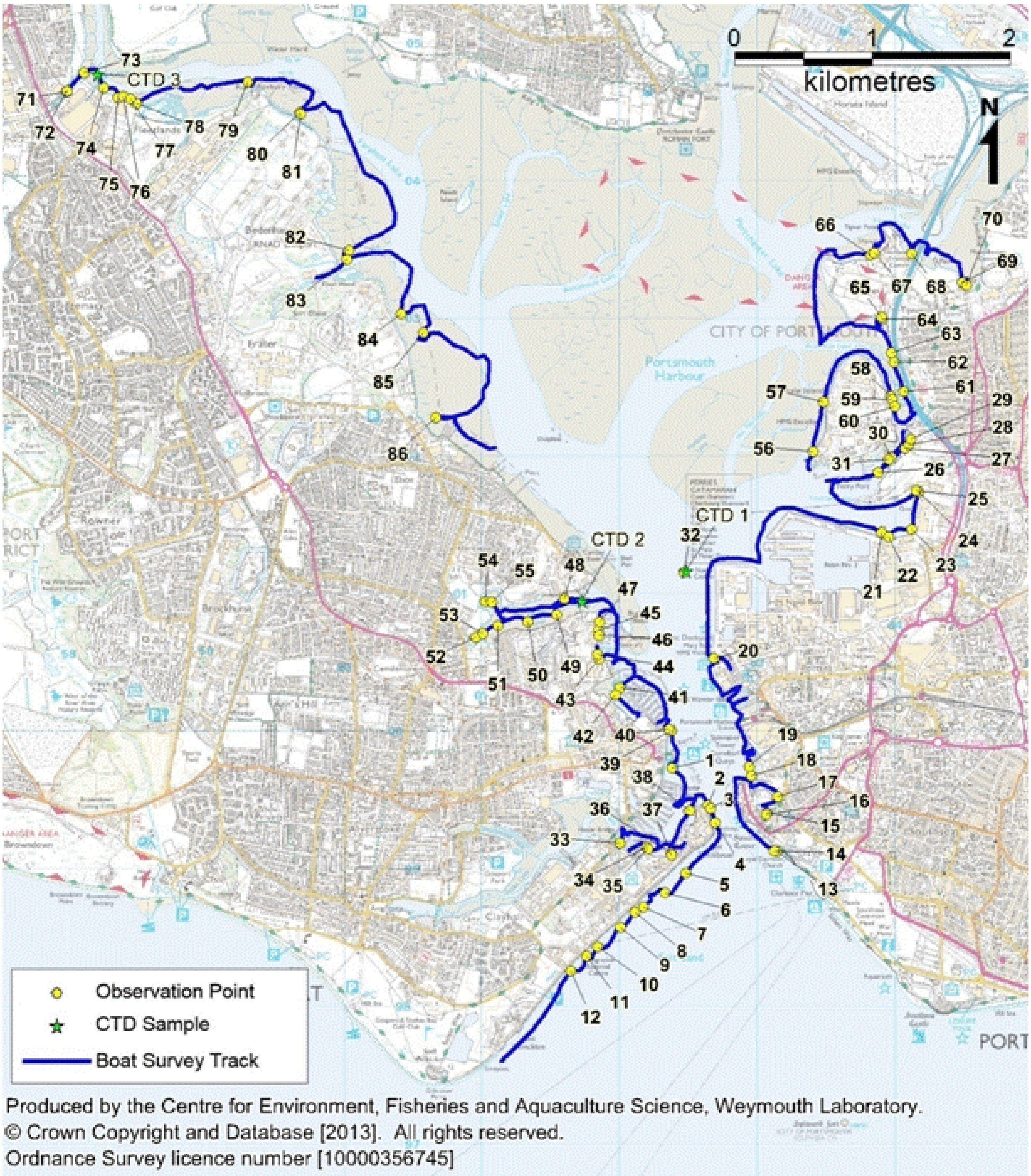

Figure XII.1:
Locations of Shoreline Observations from the boat survey - Observations 1 – 85
(see Table XII.1 for details)

Table XII.1 Details of Shoreline Observations from the boat survey

No.	NGR	Time	Description	Photo
1	SZ 62379 99735	07:07	Pipe Dripping	
2	SZ 62643 99462	07:15	Pipe (Fort Black House)	
3	SZ 62659 99441	07:19	Pipe (near tide gauge) Fort Black House	
4	SZ 62692 99336	07:20	Pipe	
5	SZ 62479 98971	07:24	Drainage Pipes (5 in a row)	
6	SZ 62330 98829	07:27	Pipe	
7	SZ 62173 98724	07:30	Seagulls approximately 5 along wall	
8	SZ 62110 98685	07:31	Pipe	
9	SZ 62003 98575	07:33	2x pipes (1 with a grill)	
10	SZ 61837 98434	07:35	Pipe (submerged)	
11	SZ 61758 98367	07:36	Drainage pipe	
12	SZ 61645 98255	07:38	Broken pipe (10 metres to left drainage pipe)	
13	SZ 63138 99127	07:57	3 pipes (Flowing) 1 pipe (Not Flowing)	
14	SZ 63123 99132	07:58	Pipe Flowing and Pier Road PS CSO submerged (FW Sample PH1) (20cm x 6cm x 1.294 m/s)	Figure XII.7
15	SZ 63067 99406	08:19	Pipe with duck valve	
16	SZ 63062 99397	08:21	Pipe with flat valve	
17	SZ 63146 99526	08:22	Pipe (Flowing fast) (FW Sample PH2)	
18	SZ 62954 99678	08:28	Pipe with flat valve	
19	SZ 62938 99745	08:30	Pipe with flat valve - 2 metre on tide gauge	
21	SU 63899 01443	09:16	Discharge culvert below	
22	SU 63951 01408	09:20	Down pipe by bridge floating oranges	
23	SU 64117 01466	09:25	Holbrook Road/Pyning Street CSO Large pipe with grid (gentle flow) and duck valve (FW Sample PH 3)	Figure XII.8
24	SU 64169 01736	09:30	Pipe (Not Flowing)	
25	SU 64151 01746	09:31	Downward Pipe - Mile House Quay	
26	SU 63878 01882	09:38	Commercial Road/Rudmore Road CSO partially	Figure XII.9
27	SU 64072 02054	09:41	Pipe dripping	
28	SU 64100 02081	09:43	Pipe	
29	SU 64112 02122	09:45	Pipe	
30	SU 63970 01991	09:50	seagulls approximately 11	
31	SU 63953 01976	09:51	Pipe Whale Island	
32	SU 62466 01151	10:00	CTD measurement	
33	SZ 62002 99186	10:22	Pipe	
34	SZ 62197 99158	10:31	series of pipes under submarine	
35	SZ 62204 99147	10:31	series of pipes under submarine	
36	SZ 62369 99117	10:33	Over 200 seagulls in the Middle of the harbour	Figure XII.10
37	SZ 62373 99104	10:34	Pipe	
38	SZ 62509 99426	10:41	Pipe	
39	SU 62355 00015	10:48	Pipe	
40	SU 62002 00316	11:02	Seagulls approximately 20	
41	SU 61965 00265	11:02	Pipe on supports	
42	SU 61848 00526	11:13	Pipe	
43	SU 61841 00561	11:15	Pipe underwater next to flap and chain	
44	SU 61844 00737	11:23	Pipe	
45	SU 61848 00698	11:26	Pipe	
46	SU 61853 00796	11:30	Pipe	
47	SU 61595 00965	11:39	Pipe x2 1 with duck valve	
48	SU 61538 00848	11:47	Pipe submerged	
49	SU 61331 00798	11:50	Pipe under yellow Southern Water Sign (Not Flowing)	
50	SU 61110 00767	11:53	Possible houseboats	Figure XII.11
51	SU 60953 00682	11:56	Large outlet plus 2 possible sluice gates	
52	SU 61005 00714	11:57	Double letterbox with rags and kiosk St. Vincent’s	Figure XII.12
53	SU 61021 00945	12:01	Large outlet with grid and pipe set back in grass	
54	SU 61070 00938	12:04	Pipe in bricked wall NW of Forton Lake	
55	SU 63403 02032	12:34	Flap valve	

Table XII.I continued

No.	NGR	Time	Description	Photo
56	SU 63477 02394	12:38	Downturned pipe with grill - Whale Island West	
57	SU 63967 02434	12:46	Pipe in concrete, half submerged open cap	
58	SU 63974 02410	12:47	Pipe in cession and crow	
59	SU 63996 02360	12:48	Pipe in small brick wall (Flap open)	
60	SU 64061 02467	12:55	Starboard Channel marker aligned with concrete box on shore - possibly intermittent?	
61	SU 63989 02680	12:58	North End Avenue Portsmouth CSO (concrete)	Figure XII.13
62	SU 63972 02747	13:00	Submerged headwall emerged concrete chamber square	
63	SU 63903 02997	13:05	Headwall adjacent to slip by Tipner wharf boatyard	
64	SU 63898 03009	13:06	Plastic downpipe by Tipner wharf boatyard pontoon (North Side)	
65	SU 63817 03463	13:28	Seamanship Training Centre Pipe near top of wall with flap (closed)	
66	SU 63847 03474	13:31	Series of small drainage pipes in sea wall to left of STC	
67	SU 64116 03470	13:38	Pipe in headwall	
68	SU 64488 03260	13:44	Plastic pipe in broken section of sea defence	
69	SU 64517 03242	13:46	Exposed manhole cover	
70	SU 57981 04646	14:28	Pipe with cover dripping and opposite pipe	
71	SU 57985 04653	14:29	Pipe opposite (Not Flowing)	
72	SU 58108 04784	14:30	Pipe submerged opposite	
73	SU 58248 04678	14:33	Submerged pipe Wicknam Lab	
74	SU 58354 04607	14:35	Submerged pipe Wicknam Lab	
75	SU 58391 04617	14:36	Series of drainage pipes approximately 6	
76	SU 58444 04594	14:37	Bricked pipe submerged	
77	SU 58493 04563	14:38	Bricked pipe submerged	
78	SU 59299 04719	14:42	West of Foxbury Point Pipe on Stilts	
79	SU 59672 04494	14:47	Sluice Gate	
80	SU 59677 04487	14:48	Flock of birds approximately 20	
81	SU 60028 03495	14:57	2 pipes with flaps	
82	SU 60014 03430	14:59	Pipe submerged	
83	SU 60409 03032	15:09	Pipe	
84	SU 60569 02896	15:11	Large pipe (Dripping)	
85	SU 60662 02280	15:21	Houseboats around 3	Figure XII.14

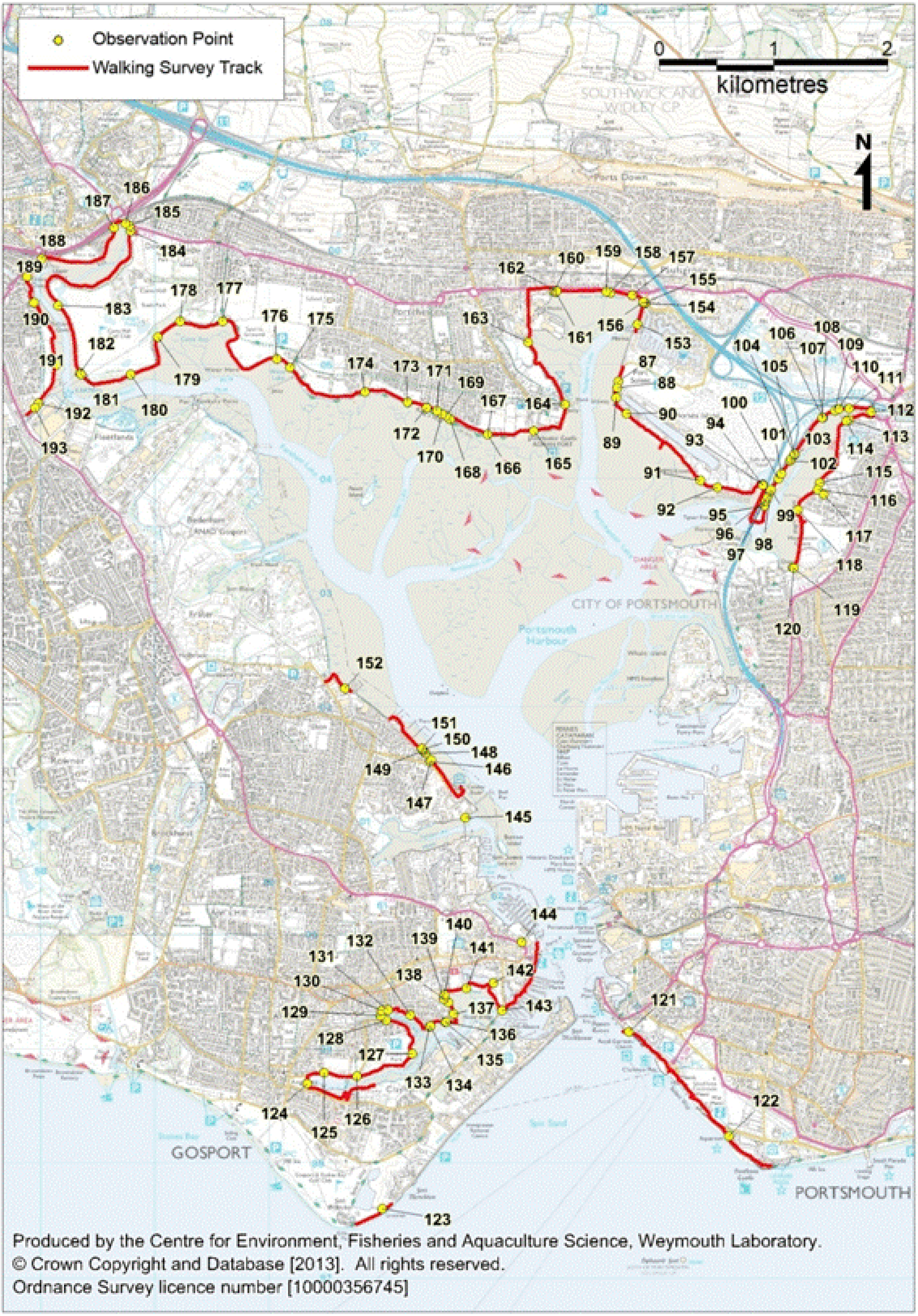

Figure XII.2:
Locations of Shoreline Observations from the pedestrian survey – Observations 86 – 192
(see Table XII.2 for details)

Table XII.2 Details of Shoreline Observations from the pedestrian survey

No.	NGR	Time	Description	Photo
86	SU 63058 04856	07:37	Drainage Pipe (Not Flowing)	
87	SU 63048 04799	07:49	Sluice gate - lake behind blocked pipe but flowing (FW Sample PH 4)	
88	SU 63038 04716	07:57	Pipe Dripping	
89	SU 63128 04571	08:04	Possible cockle collection on mudflats	Figure XII.15
90	SU 63779 03986	08:27	Pipe offshore	
91	SU 63922 03925	08:40	Pipe with flap coming through gabions	
92	SU 64324 03952	08:51	Lake	
93	SU 64323 03947	08:51	Large pipe set in concrete with grate (FW Sample PH 5)	
94	SU 64323 03947	09:20	series of drainage pipes flowing from under road - flowing	
95	SU 64338 03765	09:23	series of drainage pipes flowing from under road - flowing	
96	SU 64348 03812	09:25	Drainage pipe (Flowing)	
97	SU 64362 03842	09:26	Drainage pipe (Flowing)	
98	SU 64387 03890	09:28	Spillway (Not Flowing)	
99	SU 64396 03905	09:29	Drainage pipe (Flowing)	
100	SU 64458 04004	09:31	Drainage pipe (Flowing)	
101	SU 64485 04046	09:32	Drainage pipe (Flowing)	
102	SU 64560 04161	09:34	Drainage pipe (Flowing)	
103	SU 64570 04172	09:34	Drainage pipe (Flowing)	
104	SU 64600 04215	09:35	Drainage pipe (Flowing)	
105	SU 64602 04217	09:35	Birds on mudflats approximately 40 (oystercatcher, stern, blackheaded gull, heron)	
106	SU 64847 04540	09:41	Large pipe with drain, grill and sluice flowing	
107	SU 64848 04539	09:43	Pipe next to flowing pipe (Not flowing) (spilling drain?)	
108	SU 64846 04536	09:43	Small pipe to right of large pipe (Flowing)	Figure XII.16
109	SU 64953 04597	09:49	Drain cover above large pipe with flap (Flowing gently) Assumed typical of all drainage pipes along this shore (FW Sample PH6)	Figure XII.17
110	SU 64989 04612	09:57	Spillway (Not Flowing)	
111	SU 65081 04618	09:59	large concrete structure with manhole covers and large grid drainage pipes flowing either side pipe on opposite side of channel flowing	Figure XII.18
112	SU 65275 04586	10:09	Pipe in concrete (Not Flowing)	
113	SU 65082 04520	10:15	Lido	
114	SU 65058 04508	10:16	Large lake in line with pipe on other side of creek	
115	SU 64821 03968	10:27	Dog walkers and dog bin located on side of path	
116	SU 64803 03905	10:28	Pipe (Not flowing)	
117	SU 64859 03865	10:30	Matapan Road Surface Water Plant	
118	SU 64632 03730	10:37	Pipe - appears to be broken - football pitch behind	
119	SU 64585 03223	10:47	Large pipe (Not Flowing)	
120	SU 64595 03221	10:47	Man hole cover South West Water	
121	SZ 63151 99155	11:56	Pipe broken but flowing from wall - Seawater lagoon behind (SW Sample PH 7)	Figure XII.19
122	SZ 64023 98237	12:21	Blue pipe submerged - private discharge close to Blue Reef Aquarium (Kiddies Corner)	Figure XII.20
123	SZ 60989 97602	09:07	Drainage from golf course (FW Sample PH01)	
124	SZ 60329 98700	10:02	Village Road Alverstoke CEO (FW Sample PH02)	
125	SZ 60475 98793	10:09	Cockles	
126	SZ 60765 98763	10:13	Surface water drainage	
127	SZ 61248 98961	10:23	Large pipe on opposite bank	

Table XII.2 continued

No.	NGR	Time	Description	Photo
128	SZ 61023 99257	10:31	Surface water drainage	
129	SZ 60969 99295	10:34	2 outfalls at end of lake (not accessible)	
130	SZ 60980 99341	10:36	Alva Road Gosport PS & CEO	Figure XII.21
131	SZ 61039 99346	10:38	Surface water drainage	
132	SZ 61232 99300	10:43	Surface water drainage with sewage fungus	Figure XII.22
133	SZ 61400 99198	10:47	Surface water drainage	
134	SZ 61412 99206	10:48	Surface water drainage, broken pipe	
135	SZ 61537 99238	10:51	Surface water drainage	
136	SZ 61550 99241	10:52	Surface water drainage	
137	SZ 61614 99311	10:54	Surface water drainage	
138	SZ 61568 99410	10:56	Surface water drainage	
139	SZ 61530 99440	10:58	The Anchorage Gosport CEO (FW Sample PH03)	Figure XII.23
140	SZ 61533 99478	11:03	Possible old blocked pipe	
141	SZ 61724 99531	11:06	Large pipe with grid	
142	SZ 61960 99578	11:16	Surface water drainage, black & anoxic, sewage fungus (FW Sample PH04)	
143	SZ 62037 99340	11:23	Large pipe with grid	
144	SZ 62212 99938	12:13	Southern Water enclosure	
145	SU 61714 01031	12:34	Tidal pool next to bridge	
146	SU 61404 01522	12:49	Pumping station	
147	SU 61418 01535	12:51	Large pipe with grid	
148	SU 61368 01598	12:53	Surface water drainage	
149	SU 61346 01616	12:55	Surface water drainage	
150	SU 61333 01624	12:55	Enclosure	
151	SU 61334 01634	12:57	Disused pipe	
152	SU 60659 02163	13:14	Elson Waste Water Pumping Station CSO, with sanitary waste	Figure XII.24
153	SU 63225 05357	07:37	Surface water drainage	
154	SU 63297 05540	07:40	Pumping station for 77	
155	SU 63282 05539	07:42	Large pipe with grid (FW Sample PR01) (25cm x 50cm x 0.025 m/s)	
156	SU 63278 05550	07:51	Large pipe with grid (FW Sample PR02)	
157	SU 63182 05608	07:56	Surface water drainage	
158	SU 62989 05630	08:00	Large pipe with grid (FW Sample PR03)	
159	SU 62955 05638	08:06	Manila clam & cockle dead shell	
160	SU 62492 05641	08:14	Paulsgrove Pumping Station CSO	Figure XII.25
161	SU 62510 05633	08:15	Pipe next to CSO	
162	SU 62516 05643	08:15	Pumping station for 82	
163	SU 62264 05202	08:28	Cow Lane Portchester CEO - Culvert, anoxic smell, lots of litter	Figure XII.26
164	SU 62591 04652	08:39	Sluice for castle moat (FW Sample PR04) (100cm 5cm x 0.106m/s)	
165	SU 62317 04422	08:54	Surface water drainage (FW Sample PR05)	
166	SU 61913 04390	09:07	Entrance to a mooring. Very strong sulphur smell	Figure XII.27
167	SU 61913 04390	09:07	Private discharge	Figure XII.28
168	SU 61581 04523	09:14	Surface water drainage	
169	SU 61549 04553	09:17	Surface water drainage	
170	SU 61514 04570	09:18	Surface water drainage	
171	SU 61465 04599	09:19	Surface water drainage	
172	SU 61375 04625	09:22	Surface water drainage, pink and grey mould	Figure XII.29 & Figure XII.30
173	SU 61209 04675	09:27	Surface water drainage	

Table XII.2 continued

No.	NGR	Time	Description	Photo
174	SU 60835 04767	09:36	Wicor Mill Lane Portchester CEO	Figure XII.31
175	SU 60180 04979	10:01	Surface water drainage	
176	SU 60061 05055	10:04	Surface water drainage (FW Sample PR06)	
177	SU 59584 05381	10:22	Large pipe with grid	
178	SU 59217 05381	10:29	Surface water drainage	
179	SU 59022 05248	10:33	Surface water drainage	
180	SU 58785 04918	10:41	Surface water drainage	
181	SU 58350 04918	11:03	Stream	Figure XII.32
182	SU 58336 04928	11:04	Surface water drainage	
183	SU 58146 05518	11:16	Surface water drainage	
184	SU 58781 06169	11:40	Surface water drainage	
185	SU 58775 06217	11:41	Cams Hill, Fareham CSO	Figure XII.33
186	SU 58739 06238	11:42	Surface water drainage	
187	SU 58636 06203	11:45	Pumping station	
188	SU 58004 05929	12:10	Sluice	
189	SU 57871 05772	12:13	Sluice	
190	SU 57935 05542	12:18	Surface water drainage	
191	SU 58130 05005	12:28	Salterns Lane Fareham CEO	Figure XII.34
192	SU 57972 04662	12:34	Surface water drainage	

Sample Results

Freshwater inputs were sampled and spot discharge measurements taken, to give spot estimates of their *E. coli* loadings (Table XII.3 and Figure XII.3). Due to the extensive microbiological monitoring history of the area no shellfish sampling was considered necessary.

Table XII.3 Water sample *E. coli* results, spot flow gauging results and estimated stream loadings

Observation No	Sample	Type	Flow (m^3/s)	*E. coli* concentration (cfu/100 ml)	*E. coli* loading (cfu/day)
14	PH1	Freshwater (pipe)	0.0156	40	$5.37x10^{8}$
17	PH2	Freshwater (pipe)	-	20	-
23	PH3	Freshwater (CSO pipe)	-	8,400	-
87	PH4	Freshwater (pipe)	-	ND**	-
93	PH5	Freshwater (pipe)	-	200	-
109	PH6	Freshwater (pipe)	-	ND**	-
121	PH7	Seawater	-	10	-
123	PH01	Freshwater (surface drainage)	-	5	-
124	PH02	Freshwater (pipe)	-	380	-
139	PH03	Freshwater (CSO pipe)	-	150,000	-
142	PH04	Freshwater (pipe)	-	10	-
155	PR01	Freshwater (pipe)	0.0125	5	$5.40x10^{7}$
156	PR02	Freshwater (pipe)	-	160	-
158	PR03	Freshwater (pipe)	-	8,000	-
164	PR04	Freshwater (sluice from moat)	0.0053	300	$1.37x10^{9}$
165	PR05	Freshwater (pipe)	-	140	-
176	PR06	Freshwater (surface drainage)	-	240	-

*Numbers of *E. coli* per day introduced to coastal waters from each input, calculated from spot gauging of discharges and corresponding water sample *E. coli* results. ** Not Detectable

Figure XII.3: Locations of water samples and CTD profiles taken from Portsmouth Harbour

Relatively high concentrations *E. coli* were found in samples taken from CSO's (samples PH3 and PH03) and from a pipe at the head of the Paulsgrove Lake (sample PR03). All of the other freshwater samples were carrying low concentrations of *E. coli*.

CTD Measurements

Vertical conductivity (ppt), temperature (ºC) and depth (m) [CTD] profiles were taken at three locations within Portsmouth Harbour. Temperature and salinity profiles for these three locations are shown in Figure XII.4 - Figure XII.6.

There were slight decreases in water temperature lower in the water column, and this was most pronounced at CTD 3 where the temperature dropped from 22.5°C to 20°C in 4 metres. The salinity profile was uniform through the water column at CTD 1 and CTD 2, around 34.2–34.3ppt. At CTD 3, in the upper reaches of Fareham Creek, a slight difference in salinity between the surface waters (33.65ppt) and at 4 metres (34.25ppt) was revealed. Freshwater generally tends to contain higher concentrations of microbiological indicators than seawater, so levels of contamination may have been slightly higher towards the surface in this area. Overall, the three CTD measurements suggest that Portsmouth Harbour is well mixed, with little freshwater influence.

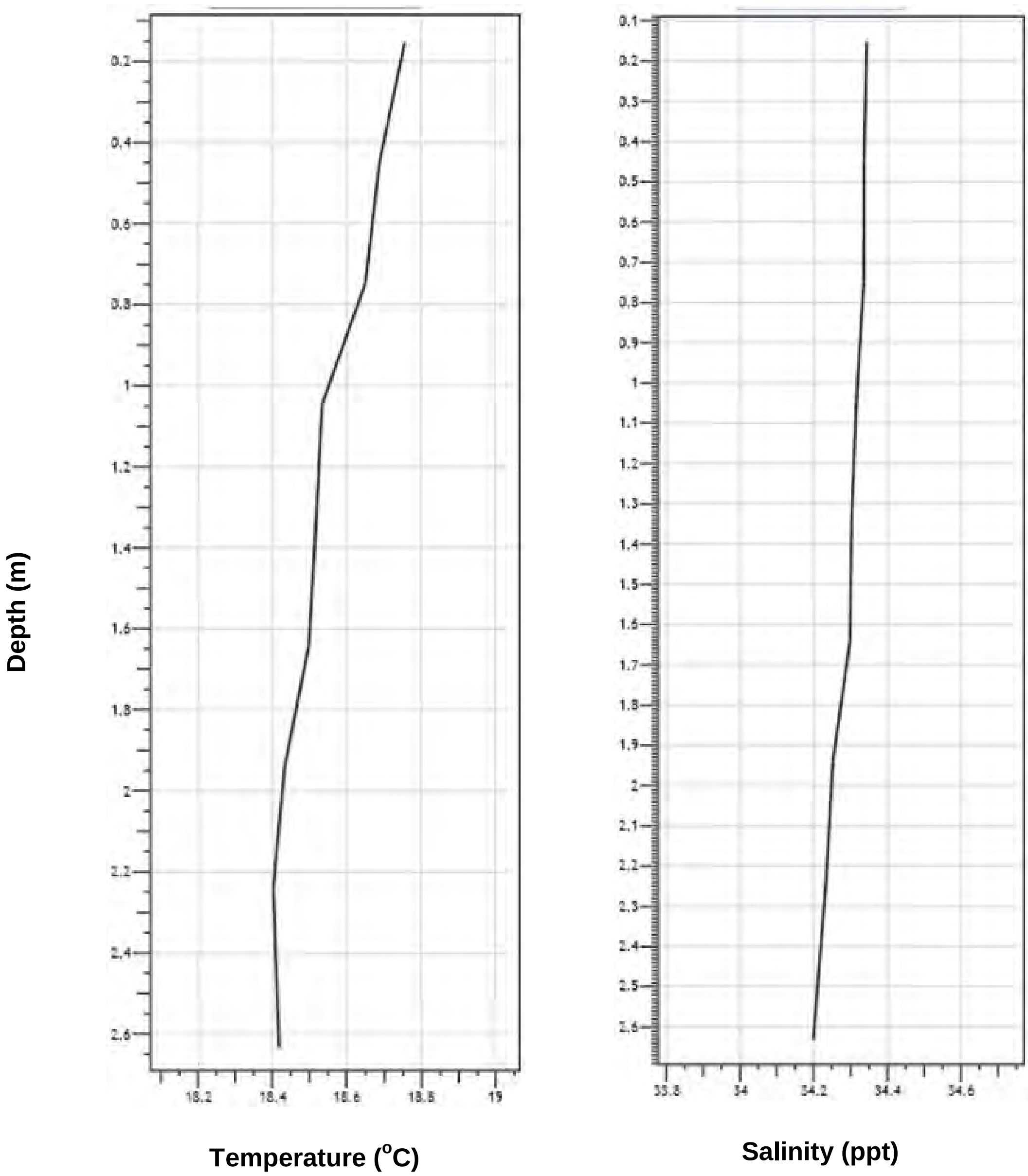

Figure XII.4: Temperature and salinity profiles CTD 1 (observation 32)

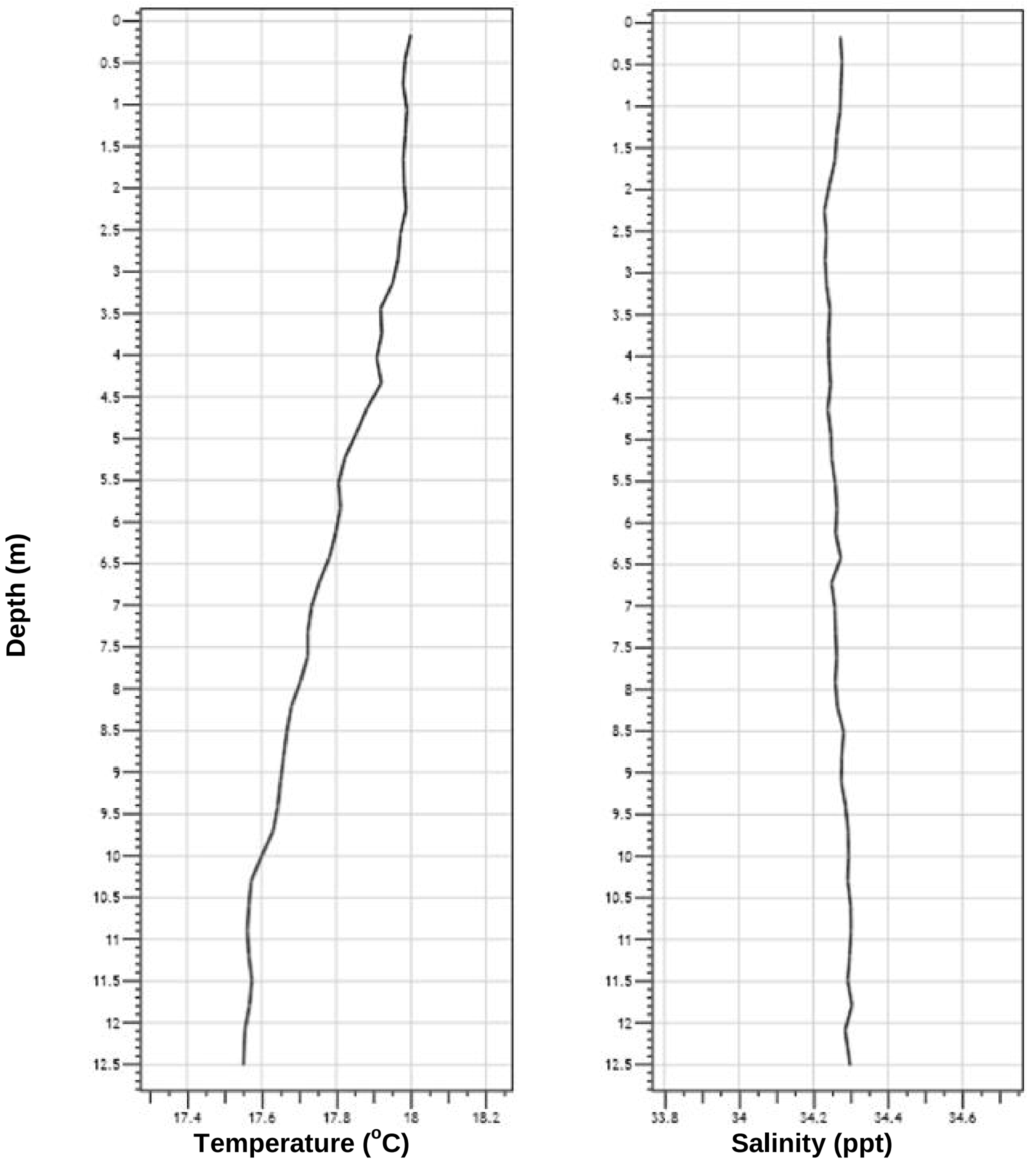

Figure XII.5: Temperature and salinity profiles CTD 2

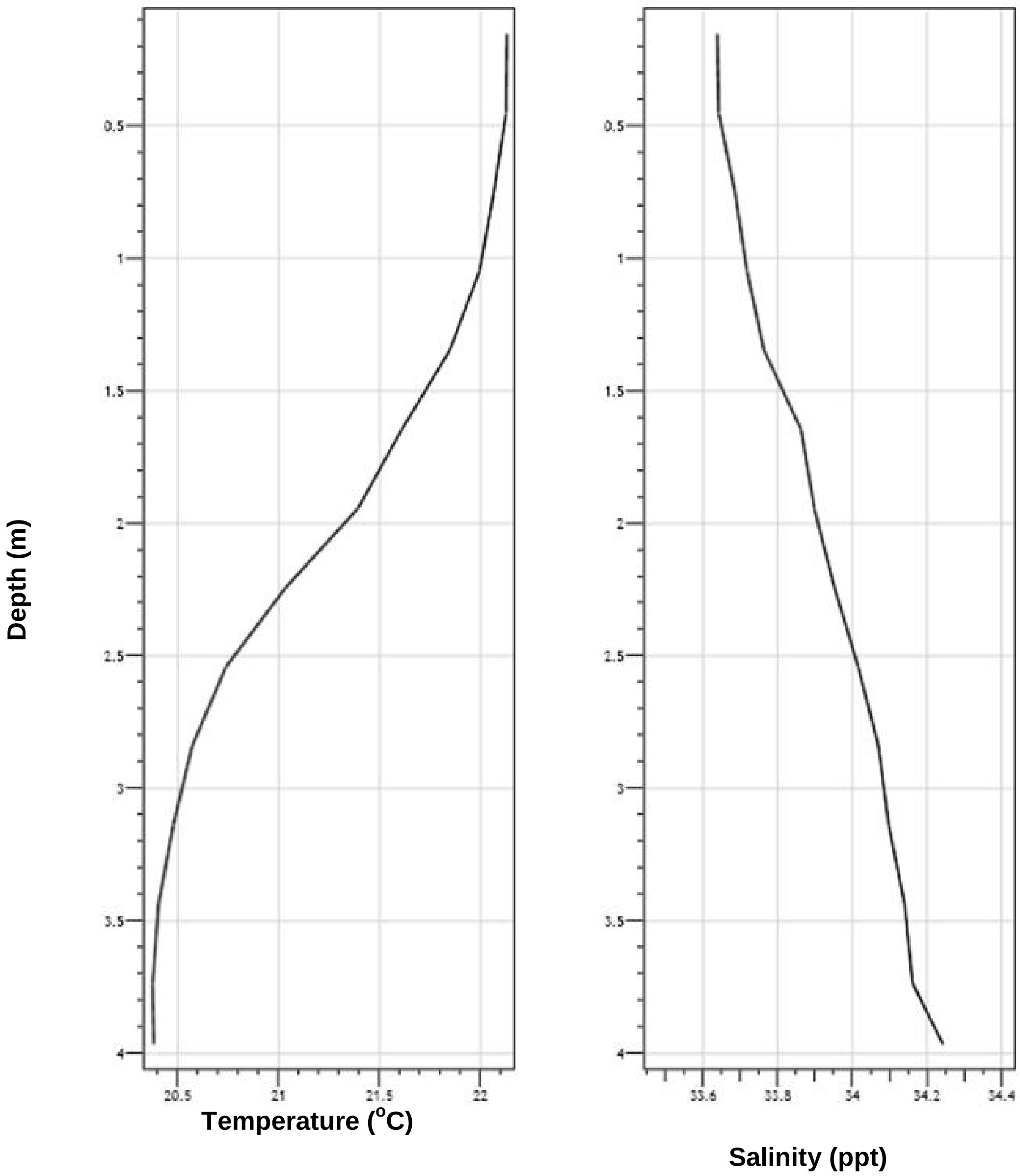

Figure XII.6: Temperature and salinity profiles CTD 3

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

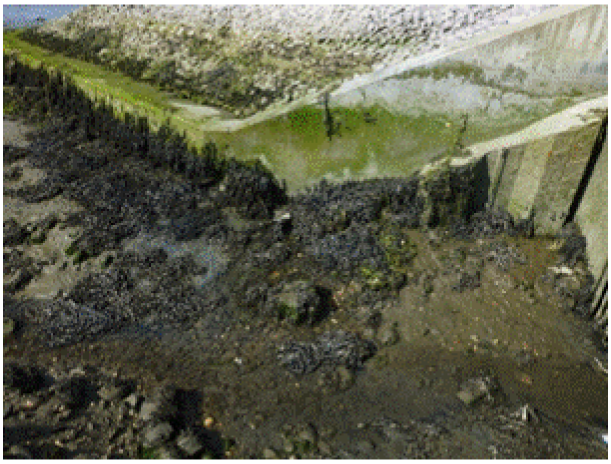

Figure XII.16

Figure XII.17

Figure XII.18

Figure XII.19

Figure XII.20

Figure XII.21

Figure XII.22

Figure XII.23

Figure XII.24

Figure XII.25

Figure XII.26

Figure XII.27

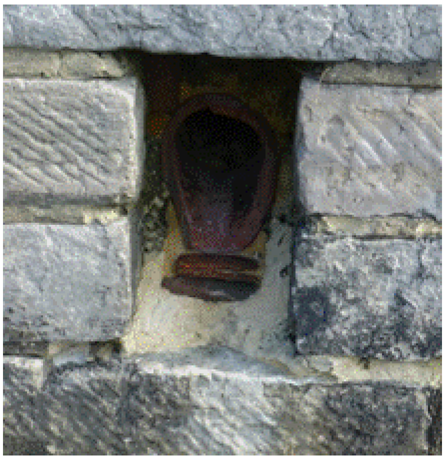

Figure XII.28

Figure XII.29

Figure XII.30

Figure XII.31

Figure XII.32

Figure XII.33

Figure XII.34

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List of Abbreviations

AONB	Area of Outstanding Natural Beauty
BMPA	Bivalve Mollusc Production Area
CD	Chart Datum
Cefas	Centre for Environment Fisheries & Aquaculture Science
CFU	Colony Forming Units
CSO	Combined Sewer Overflow
CZ	Classification Zone
Defra	Department for Environment, Food and Rural Affairs
DWF	Dry Weather Flow
EA	Environment Agency
E. coli	*Escherichia coli*
EC	European Community
EEC	European Economic Community
EO	Emergency Overflow
FIL	Fluid and Intravalvular Liquid
FSA	Food Standards Agency
GM	Geometric Mean
IFCA	Inshore Fisheries and Conservation Authority
ISO	International Organization for Standardization
km	Kilometre
LEA (LFA)	Local Enforcement Authority formerly Local Food Authority
M	Million
m	Metres
ml	Millilitres
mm	Millimetres
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MPN	Most Probable Number
NM	Nautical Miles
NRA	National Rivers Authority
NWSFC	North Western Sea Fisheries Committee
OSGB36	Ordnance Survey Great Britain 1936
mtDNA	Mitochondrial DNA
PS	Pumping Station
RMP	Representative Monitoring Point
SAC	Special Area of Conservation
SHS	Cefas Shellfish Hygiene System, integrated database and mapping application
SPA	Special Protection Area
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.
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 Nth root of the product of those numbers. It is more usually calculated by obtaining the mean of the logarithms of the numbers and then taking the 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.
Tolerance	Maximum acceptable distance from location of RMP at which sampling may be undertaken.
Secondary Treatment	Treatment applied to breakdown and reduce the amount of solids by helping bacteria and other microorganisms consume the organic material in the sewage or further treatment of settled sewage, generally by biological oxidation.
Sewage	Sewage can be defined as liquid, of whatever quality that is or has been in a sewer. It consists of waterborne waste from domestic, trade and industrial sources together with rainfall from subsoil and surface water.
Sewage Treatment Works (STW)	Facility for treating the waste water from predominantly domestic and trade premises.
Sewer	A pipe for the transport of sewage.
Sewerage	A system of connected sewers, often incorporating inter-stage pumping stations and overflows.
Storm Water	Rainfall which runs off roofs, roads, gulleys, etc. In some areas, storm water is collected and discharged to separate sewers, whilst in combined sewers it forms a diluted sewage.
Waste water	Any waste water but see also “sewage”.

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