Shellfish Water Quality Investigation Report

Portsmouth Harbour

Shellfish Water Quality Investigation Report

Portsmouth Harbour

Submitted to:	Defra and Environment Agency
Date submitted:	25 September 2012
Report compiled by:	Carlos J. A. Campos, Owen C. Morgan, Nicola Mitchard, Ian Udal
Approved by:	Simon Kershaw (Cefas)
Version & date:	1.1 (May 2012)

Table of contents

1 Background

Portsmouth Harbour shellfish water (Figure 1) has shown poor compliance with the faecal coliform guideline standard of the Shellfish Waters Directive (SWD; 300 faecal coliforms/100ml shellfish flesh in 75% samples; European Communities, 2006) since its designation in 1999 (Table 1).

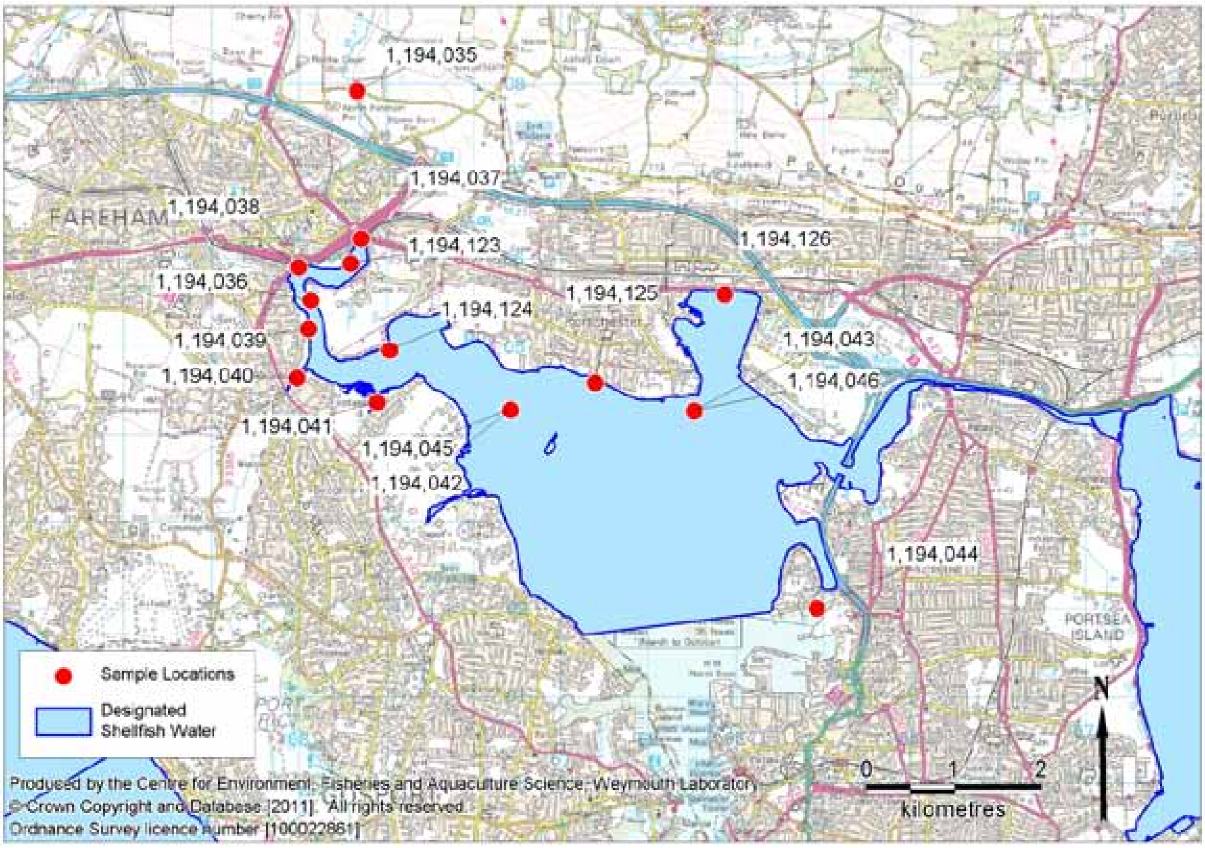


Figure 1. Portsmouth Harbour shellfish water showing locations of sites sampled for the purposes of this investigation. Legends of sampling points represent sites listed in Table 5.

Median levels of faecal coliforms in the water column showed an increasing trend during the period 2001–2008 (Acornley et al., 2010).

Table 1. Historical compliance of Portsmouth shellfish water with the guideline faecal coliform standard of the Shellfish Waters Directive, 2001–2011.

Year of designation	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1999	Fail	Fail	Fail	Pass	Fail	Fail	Fail	Pass	Fail	Fail	Fail

Source: Environment Agency.

In 2007, the shellfish hygiene classification[1] status of Portsmouth–Western Beds (*Mercenaria mercenaria*; *O. edulis*) was upgraded from class C to B (Cefas, 2011). More recently, as of February 2012, all production areas had achieved a long-term B classification (Table 2).

Remedial action was completed during the period 2004–2006 to a number of intermittent discharges (IDs) which had been identified as having a significant or potentially significant impact upon the shellfish water. The Environment Agency (EA) Pollution Reduction Plan indicates that further discharges may require improvement in the future along with attenuation of diffuse pollution from urban and agricultural land (Environment Agency, 2009) to help ensure consistent compliance with the SWD guideline standard in the future.

This report summarises the main results of desk-based and field investigations carried out by Cefas and the EA in 2011 aimed to quantify the contribution of point and diffuse sources of pollution affecting the microbiological quality of the shellfish water. The specific objectives of these investigations were:

§ To determine the impact of sewage discharges upon the quality of the shellfish water.
§ To assess the contribution of diffuse pollution originated from agricultural land.
§ To assess the effect of water circulation (currents and tide) on shellfish flesh quality.
§ To recommend measures to help ensure that faecal coliform concentrations meet the guideline standard of the SWD.

[1] Classification in accordance with Regulation (EC) No 854/2004 (European Communities, 2004).

Table 2. Classifications of shellfish harvesting areas under Regulation (EC) No 854/2004.

Bed name	Bed ID	Species	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Portsmouth - All beds	B020B/C	*O. edulis*	-	-	B	B	B	B-LT	-	-	-	-	-	-
Portsmouth - All beds	B020B/C	*M. mercenaria*	-	-	B	B	B	B-LT	-	-	-	-	-	-
Portsmouth - Eastern beds	B020C	*O. edulis*	B	B[2]	-	-	-	-	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Portsmouth - Eastern beds	B020C	*M. mercenaria*	B	B[2]	-	-	-	-	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Portsmouth - Western beds	B020B	*O. edulis*	B[1]	B	-	-	-	-	C	B	B	B	B-LT	B-LT
Portsmouth - Western beds	B020B	*M. mercenaria*	B[1]	B	-	-	-	-	C	B	B	B	B-LT	B-LT

1 - Area classified at higher level due to results close to the tolerance limit.

2 - Area classified at higher level as there was evidence that exceptional factors may have affected the sampling results (e.g. sewage treatment works failure, greater than 1 in 5 year rainfall event, etc.).

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

2 Sources of microbiological pollution

2.1 Sewage discharges

Waste-water treatment facilities in the Portsmouth Harbour catchment are provided by Southern Water Services Ltd (SWS). Most of the population in the catchment is connected to the public sewerage network. SWS operate three sewage treatment works [Budds Farm STW (approximately 10km from the shellfish water boundary); Peel Common STW (approximately 7.5km from the shellfish water) and Southwick STW (approximately 6km from the shellfish water)] which discharge secondary treated sewage effluent (Table 3; Figure 2). Typical levels of faecal coliforms in secondary treated sewage effluent under base and high flow conditions as observed in a range of effluents by Kay *et al*. (2008) are 3.3 x 10^5 and 5 x 10^5 cfu $100ml^{-1}$ (geometric mean). Budds Farm STW and Peel Common STW discharge outside the harbour to the Solent by means of long sea outfalls.

Hydrodynamic modelling undertaken for the Portsmouth and Havant Urban Treatment Scheme indicates that the bacterial plumes from Peel Common STW and Budds Farm STW have an impact upon the shellfish water. The EA recommended upgrading the treatment level at these STW to UV disinfection (tertiary treatment) during the AMP5 cycle of investment by 2015 to help ensure compliance with the standards of the SWD (Environment Agency, 2009). Peel Common is also to receive UV treatment. Budds Farm will not as tertiary treatment installed to remove nitrogen has been shown to remove bacteria more effectively than standard secondary treatment.

In addition to the continuous discharges, there are 75 IDs [including combined sewer overflows (CSOs), pumping station overflows], many of which discharge directly to the shellfish water. The typical geometric mean faecal coliform concentrations in storm sewage overflows is 2.5 x 10^6 cfu $100ml^{-1}$ (Kay *et al*., 2008). Event/duration monitoring is currently in place in some of these IDs. The monitoring data supplied by SWS has been reviewed by the EA to assess if further improvements are required such as increasing the volume of storage to limit the spill frequency for unsatisfactory CSOs[2]. A review of spill data for the period April 2008–March 2009 did not evidence any problems with spill frequency at these discharges.

[2] The Government (Urban Waste Water Treatment (England and Wales) Regulations Guidance Note, July 1997 states that a CSO is "unsatisfactory" if it:

- Causes significant visual or aesthetic impact due to solids, fungus and has a history of justified public complaint;
- Causes or makes a significant contribution to a deterioration in river chemical or biological class;

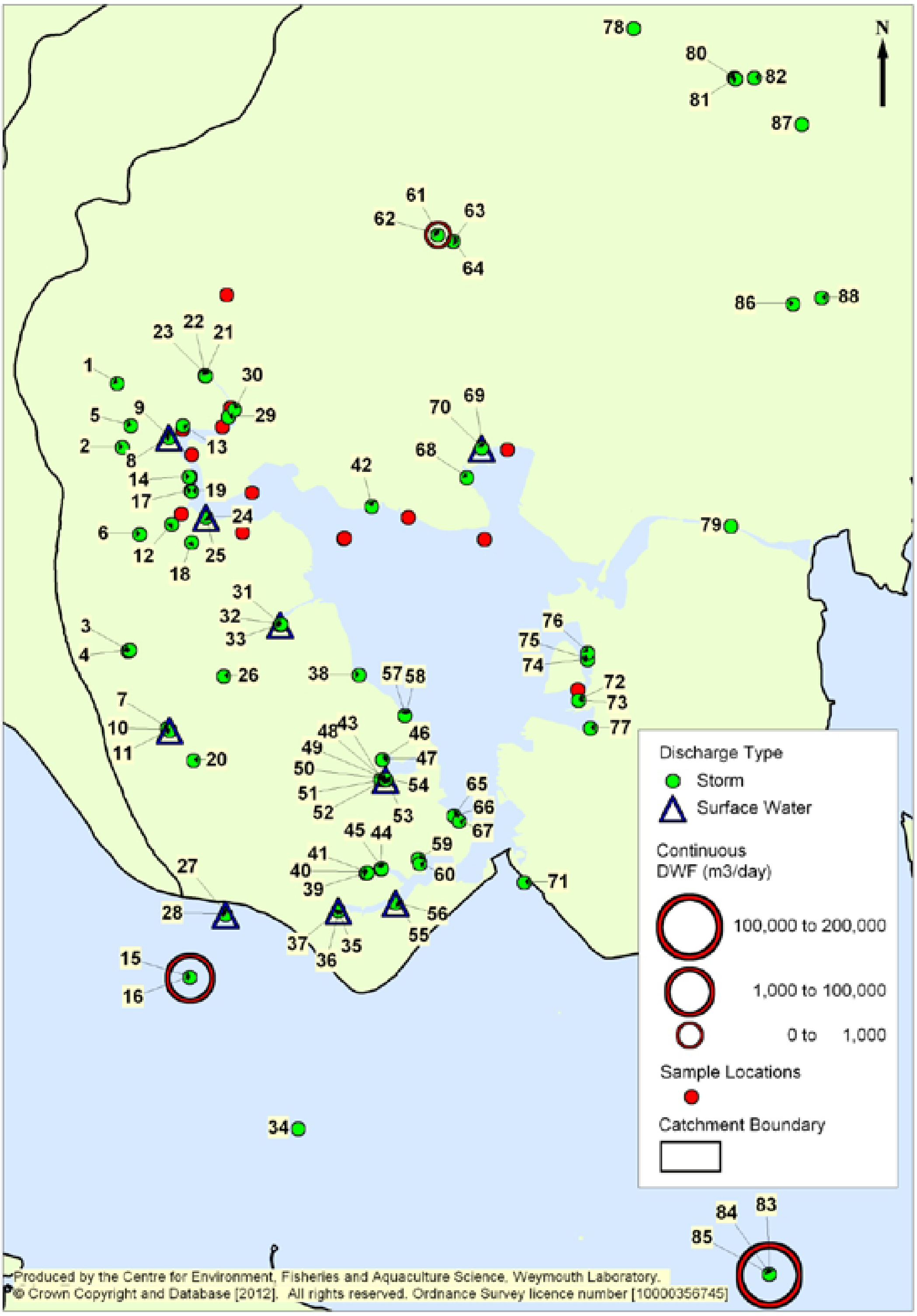


Figure 2. Significant continuous and intermittent sewage discharges to Portsmouth Harbour shellfish water.

- Causes or makes a significant contribution to a failure to comply with Bathing Water Quality Standards for identified bathing waters;
- Operates in dry weather conditions;
- Operates in breach of consent conditions provided that they are still appropriate;
- Causes a breach of water quality standards (EQS) and other EC Directives.

Table 3. Significant continuous and intermittent discharges to Portsmouth Harbour shellfish water.

Map ID	Discharge name	Receiving water	NGR (outlet)	DWF (m^3/day)	Maximum flow rate (m^3/day)	Discharge type
1	STORM OVERFLOW AT ARUNDEL DRIVE	BLACK BROOK	SU5701006600	N/A	-	Storm overflow
2	REDLANDS LANE FAREHAM CSO	BLACK BROOK	SU5709005640	N/A	5.6	Storm overflow
3	NEWGATE LANE WPS CEO	DITCH TO THE RIVER ALVER	SU5718002590	N/A	79	Storm overflow
4	PEEL COMMON PUMPING STATION	FRESHWATER RIVER	SU5720002600	N/A	-	Storm overflow
5	THE GILLIES FAREHAM CSO	BLACKBROOK STREAM	SU5722005970	N/A	390	Storm overflow
6	COTSWOLD WALK CSO	HOEFORD STREAM	SU5735004340	N/A	5.6	Storm overflow
7	ACORN CLOSE PS	RIVER ALVER	SU5777001430	N/A	-	Storm overflow
8	ELMHURST ROAD (COMPASS POINT) CSO	BLACK BROOK	SU5779005790	N/A	236	Storm overflow
9	ELMHURST ROAD (COMPASS POINT) CSO	BLACK BROOK	SU5779005790	N/A	-	Surface water
10	BROOMFIELD CRESCENT	RIVER ALVER	SU5780001400	N/A	-	Storm overflow
11	BROOMFIELD CRESCENT	RIVER ALVER	SU5780001400	N/A	-	Surface water
12	HOEFORD FAREHAM CEO	HOEFORD LAKE	SU5783004490	N/A	9.16	Storm overflow
13	QUAY STREET, FAREHAM CSO	FAREHAM CREEK/PORTSMOUTH HBR	SU5800005970	N/A	-	Storm overflow
14	SALTERNS LANE FAREHAM O/S 12 CSO	PORTSMOUTH HARBOUR	SU5809005200	N/A	699.5	Storm overflow
15	**PEEL COMMON WWTW**	THE SOLENT	SZ5810097700	59,683	-	Secondary treated sewage
16	PEEL COMMON WWTW	THE SOLENT	SZ5810097700	N/A	1,450	Storm tank discharge
17	SALTERNS LANE FAREHAM CEO	PORTSMOUTH HARBOUR	SU5812004990	N/A	759	Storm overflow
18	WYCH LANE/FAREHAM RD O/FLOW	SALINE ESTUARY	SU5813004220	N/A	-	Storm overflow
19	SALTERNS LANE PS	FAREHAM LAKE	SU5813004980	N/A	-	Storm overflow
20	ROWNER PUMPING STATION	SALINE ESTUARY	SU5816000950	N/A	-	Storm overflow
21	HIGH STREET FAREHAM CSO	WALLINGTON RIVER	SU5833006720	N/A	34	Storm overflow
22	WALLINGTON HILL CSO	RIVER WALLINGTON	SU5833006720	N/A	29	Storm overflow

23	WICKHAM ROAD FAREHAM WPS CSO	RIVER WALLINGTON	SU5834006710	N/A	120	Storm overflow
24	CYANAMID PS	PORTSMOUTH HARBOUR	SU5835004590	N/A	-	Storm overflow
25	CYANAMID PS	PORTSMOUTH HARBOUR	SU5835004590	N/A	-	Surface water
26	GREEN CRESCENT O/FLOW	SALINE ESTUARY	SU5861002210	N/A	-	Storm overflow
27	BROWNDOWN PUMPING STATION	STOKES BAY	SZ5864098640	N/A	-	Storm overflow
28	BROWNDOWN PUMPING STATION	STOKES BAY	SZ5864098640	N/A	-	Surface water
29	BRIDGEFOOT PUMPING STATION	FAREHAM CREEK/PORTSMOUTH HBR	SU5868006100	N/A	-	Storm overflow
30	CAMS HILL, FAREHAM CSO	FAREHAM CREEK/PORTSMOUTH HBR	SU5877006210	N/A	186.4	Storm overflow
31	TICHBOURNE WAY PS	PORTSMOUTH HARBOUR	SU5946002980	N/A	-	Storm overflow
32	TICHBOURNE WAY PS	PORTSMOUTH HARBOUR	SU5946002980	N/A	-	Surface water
33	BREWERS LANE GOSPORT CSO	FRATER LAKE, PORTSMOUTH HBR	SU5947002990	N/A	79.0	Storm overflow
34	RYDE (APPLEY PARK) HEADWORKS WPS	THE SOLENT	SZ5973095430	N/A	122.0	Storm overflow
35	VILLAGE ROAD PS	STOKE LAKE	SZ6033098700	N/A	-	Storm overflow
36	VILLAGE ROAD PS	STOKE LAKE	SZ6033098700	N/A	-	Surface water
37	VILLAGE ROAD ALVERSTOKE CEO	STOKE LAKE	SZ6033098700	N/A	91.2	Storm overflow
38	ELSON WASTE WATER PUMPING STATION	FAREHAM LAKE/R.WALLINGTON EST	SU6064002230	N/A	-	Storm overflow
39	BURY ROAD GOSPORT CEO	WORKHOUSE LAKE	SZ6075099260	N/A	62.0	Storm overflow
40	BURY CROSS HOSPITAL PUMPING STN	SALINE ESTUARY	SZ6076099270	N/A	-	Storm overflow
41	FOSTER ROAD GOSPORT WPS CEO	WORKHOUSE LAKE, PORTSMOUTH HBR	SZ6076099270	N/A	10.0	Storm overflow
42	WICOR MILL LANE PORTCHESTER CEO	PORTSMOUTH HARBOUR	SU6083004750	N/A	98.0	Storm overflow
43	ST VINCENTS PS	FORTON LAKE - PORTSMOUTH HBR	SU6096000660	N/A	-	Storm overflow
44	ALVER ROAD GOSPORT CEO	WORKHOUSE LAKE	SZ6097099320	N/A	57.0	Storm overflow
45	ALVER ROAD PS	WORKHOUSE LAKE	SZ6098099330	N/A	0	Storm overflow
46	GROVE ROAD GOSPORT CSO	PORTSMOUTH HARBOUR	SU6099000960	N/A	51.0	Storm overflow
47	GROVE ROAD GOSPORT WASTEWATER PS	FORTON LAKE - PORTSMOUTH HBR	SU6099000960	N/A	0	Storm overflow
48	MIDDLECROFT LANE GOSPORT CSO	PORTSMOUTH HARBOUR	SU6102000650	N/A	178.2	Storm overflow
49	CAMBRIDGE ROAD/BROCKHURST ROAD PS	PORTSMOUTH HARBOUR	SU6104000660	N/A	-	Storm overflow
50	CAMBRIDGE ROAD/BROCKHURST ROAD PS	PORTSMOUTH HARBOUR	SU6104000660	N/A	-	Surface water

51	LEES LANE PS	PORTSMOUTH HARBOUR	SU6104000660	N/A	-	Storm overflow
52	LEES LANE PS	PORTSMOUTH HARBOUR	SU6104000660	N/A	-	Surface water
53	CAMBRIDGE ROAD/BROCKHURST ROAD PS	PORTSMOUTH HARBOUR	SU6104000660	N/A	74.4	Storm overflow
54	LEES LANE GOSPORT CEO	PORTSMOUTH HARBOUR	SU6104000663	N/A	90.9	Storm overflow
55	CLAYHALL ROAD/DOLPHIN WAY PS	STOKE LAKE - PORTSMOUTH HBR	SZ6119098810	N/A	-	Storm overflow
56	CLAYHALL ROAD/DOLPHIN WAY PS	STOKE LAKE - PORTSMOUTH HBR	SZ6119098810	N/A	-	Surface water
57	PRIORY ROAD PS	PORTSMOUTH HARBOUR	SU6133001620	N/A	-	Storm overflow
58	HARDWAY CEO, PRIORY ROAD, GOSPORT	PORTSMOUTH HARBOUR	SU6133001620	N/A	19.0	Storm overflow
59	THE ANCHORAGE GOSPORT CEO	PORTSMOUTH HARBOUR	SZ6153099470	N/A	44.0	Storm overflow
60	HENRY STREET PS	HASLAR LAKE	SZ6155099400	N/A	-	Storm overflow
61	**SOUTHWICK STW**	RIVER WALLINGTON	SU6182008820	540	-	Secondary treated sewage
62	SOUTHWICK STW	RIVER WALLINGTON	SU6182008820	N/A	12.0	Storm tank discharge
63	NEWMANS BRIDGE SOUTHWICK CEO	RIVER WALLINGTON	SU6205008730	N/A	10.8	Storm overflow
64	SEWAGE PUMPING STATION	FRESHWATER RIVER	SU6205008730	N/A	-	Storm overflow
65	HARBOUR ROAD GOSPORT CEO	PORTSMOUTH HARBOUR	SU6206000120	N/A	30.7	Storm overflow
66	ST MATTHEWS SQUARE GOSPORT CEO	PORTSMOUTH HARBOUR	SU6206000120	N/A	-	Storm overflow
67	MUMBY ROAD GOSPORT WPS/CEO	PORTSMOUTH HARBOUR	SU6214000040	N/A	-	Storm overflow
68	COW LANE PORTCHESTER CEO	PORTSMOUTH HARBOUR	SU6226005190	N/A	87.8	Storm overflow
69	PAULSGROVE PS	PORTSMOUTH HARBOUR	SU6248005630	N/A	-	Surface water
70	PAULSGROVE PS	PORTSMOUTH HARBOUR	SU6248005630	N/A	-	Storm overflow
71	PIER ROAD PS	THE SOLENT	SZ6312099120	N/A	395	Storm overflow
72	COMMERCIAL ROAD/RUDMORE ROAD CSO	PORTSMOUTH HARBOUR	SU6393001850	N/A	88.0	Storm overflow
73	MILE END ROAD CSO	PORTSMOUTH HARBOUR	SU6393001850	N/A	88.0	Storm overflow
74	NORTH END AVENUE PORTSMOUTH CSO	PORTSMOUTH HARBOUR	SU6407002460	N/A	66.4	Storm overflow
75	WIDLEY ROAD PORTSMOUTH CSO	PORTSMOUTH HARBOUR	SU6407002460	N/A	23.8	Storm overflow
76	GRUNEISON ROAD STORM PS	PORTSMOUTH HARBOUR	SU6407002560	N/A	-	Storm overflow
77	HOLBROOK ROAD/PYNING STREET CSO	PORTSMOUTH HARBOUR	SU6411001430	N/A	-	Storm overflow
78	PUMPING STATION NO. 2	FRESHWATER RIVER	SU6476011920	N/A	-	Storm overflow

79	COSHAM PS	PORTS CREEK	SU6622004460	N/A	-	Storm overflow
80	HAMBLEDON PS	SHEEPWASH TRIBUTARY	SU6627011180	N/A	160.0	Storm overflow
81	FOREST ROAD DENMEAD NO.2 CSO	RIVER WALLINGTON	SU6629011160	N/A	113.6	Storm overflow
82	PUMPING STATION NO. 1	FRESHWATER RIVER	SU6657011180	N/A	-	Storm overflow
83	**BUDDS FARM WWTW**	THE SOLENT	SZ6679093250	108,853	-	Secondary treated sewage
84	BUDDS FARM WWTW	THE SOLENT	SZ6679093250	N/A	3,600.0	Storm tank discharge
85	HENDERSON ROAD EASTNEY WPS	THE SOLENT	SZ6679093250	N/A	1,379.0	Storm overflow
86	LONE VALLEY/SERPENTINE ROAD CSO	TRIBUTARY OF RIVER WALLINGTON	SU6715007790	N/A	4.2	Storm overflow
87	HAMBLETON ROAD	FRESHWATER RIVER	SU6728010480	N/A	-	Storm overflow
88	WESTBROOK GROVE PURBROOK CEO	WALLINGTON RIVER VIA DRAIN	SU6758007880	N/A	193.7	Storm overflow

CSO - combined sewer overflow.
CEO - combined emergency overflow.
DWF - dry weather flow
NGR - national grid reference.
PS - pumping station.
STW - sewage treatment works.
WWTW - waste-water treatment works.

3 Coastal survey

3.1 Aim

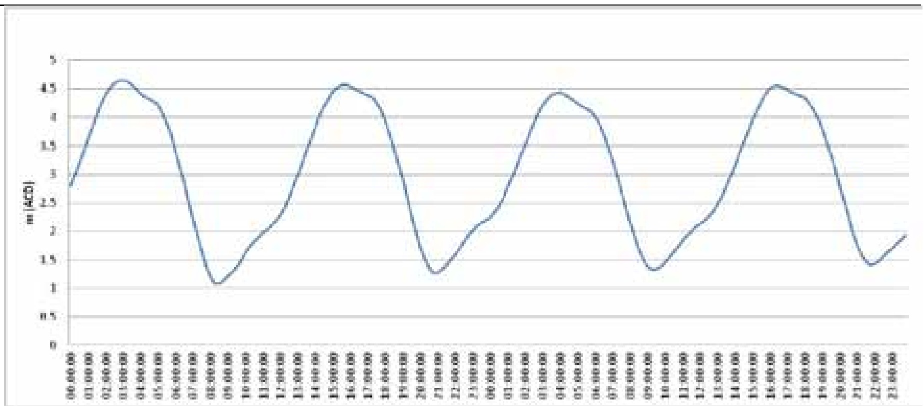
The aim of the investigation was to confirm the presence of potentially contaminating sources to Portsmouth Harbour shellfish water identified during the desk-based study and confirm the existence of harvestable shellfish stocks to help identify appropriate locations for sampling under the shellfish waters monitoring programme.

3.2 Results

The harbour shoreline was surveyed from a hovercraft during low water and under dry weather on the 7 June 2011. Samples of water and shellfish were collected during the survey for enumeration of faecal indicator organisms. Water samples collected include watercourses, discharges of unknown type/origin (Table 4). Additional shellfish samples were collected from along the northern shore by EA staff on the 8 June 2011.

Table 4. Summary of observations made during the shoreline survey in Portsmouth Harbour on 7 June 2011.

Production area	Portsmouth Harbour	
Shellfish hygiene bed names	Portsmouth Harbour	Western Beds
Area of shellfish beds	Portsmouth Harbour: 1.576km^2 (*Mercenaria mercenaria*) Western Beds: 1.736km^2 (*Ostrea edulis*)	
Shellfish water	Portsmouth Harbour (12.23km^2)	
EA Officer	Hana Abdul-Wahab	
Cefas Officer	Carlos Campos	
Date/time of surveys:	7 June 2011 (07:00–12:30) 8 June 2011 (09:00 – 12:00)	
Extent of survey Area	Wallington River at North Fareham. Portsmouth Harbour (Heavy Reach, Fareham lake, Portchester Lake, Harbour area, Fountain Lake)	
Map/Chart References	OS Explorer No. 119; Imray Chart No. 2.200/5	
Predicted tides at Portsmouth	High Water (time/height)	03:23 (4.4m)
	Low Water (time/height)	09:04 (1m)

Admiralty TotalTide UKHO	 Figure 3. Water levels recorded on survey days from POL tide gauge in Portsmouth Harbour. http://www.pol.ac.uk/ntslf/data.html. Site: Portsmouth (Port: P008) Latitude:50.8026 Longitude:-1.1118 Proudman Oceanographic Laboratory Datum information: The data refer to Admiralty Chart Datum (ACD)
Weather forecast	Met Office Inshore Waters: Selsey Bill to Lyme Regis Wind: variable (3 or4 becoming southwest 4 or 5 later) Sea state: smooth or slight Weather: showers at first Visibility: good
Air temperature	11°C
Wind	14Km h^{-1} (07:00h)
Precipitation	None at time of survey
Cloud cover	16% (10:00)
Rivers/streams/spring s (gauged) BNG	Wallington River North Fareham/Spurlings Farm: 0.094 m^3 s^{-1} (Figure 3A) Cams Hall golf course (stream from lake) (Figure 3B) Wallington River at Wallington (A27 bridge) (Figure 3C) Stream Heavy Reach creek adj. STW
Key discharges identified (Cefas database)	Upper Wharf/Fareham CSO (Figure 3D) Salterns Lane CSO (Figure 3E) Wicor Mill Lane WPS CSO/EO Cyanamid PS
Other discharges	Unidentified discharge at West End adj. STW. Unidentified discharge Cams Hall Unidentified discharge Fleetlands Creek (Figure 3F)

Boats/ports	Large number of annual/seasonal moorings along Heavy Reach, Fareham Lake Yachts and dinghies along Heavy Reach at Upper Quay, Salterns Quay Wicormarine boatyard with deepwater pontoons, swinging, tidal moorings and pontoon moorings Slipway at Wicormarine, Fountain Lake Tidal berths alongside the Wicor Lake jetty with larger vessels Port Solent Marina Dinghies stored ashore at Wicormarine, Port Solent marina and Fountain Lake (Figure 3I) Naval base/continental ferry port at Portsmouth
Animals observed	Birds: waders, ducks, wildfowl in shallow waters over the mudflats and creeks and channels at low water Dogs: dog walking Wallington River at Wallington
Sewage related debris	None observed
Samples taken	See Figure 4 and Table 5 below
Water appearance	Turbid/sediment resuspension with incoming tide in the upper reaches of the harbour Clear in the upper tidal ranges of Fleetlands creek and tidal creeks at Heavy Reach in the vicinity of *Spartina* marshes Muddy creeks extensively covered by green algae (*Ulva*)
Bivalve harvesting activity	Bait/shellfish hand-picking(?) north of Peewit Island (Figure 3G)
Land use adjacent to shellfish water	Vegetation: Improved grassland interspersed by woodland areas at North Fareham Urban and suburban areas at Wallington, West End, Portchester and City of Portsmouth Naval Base at Portsmouth/heliport at Fleetlands Industrial/services North of Bedenham
Topography in the lower catchment	Flat land (<10m OD)
Shellfisheries	Juvenile and commercial sized cockles at Fareham Lake and Portchester Lake (Figure 3H) High densities of adult Manila clams at Portchester Lake American hard clam, cockle and peppery furrow shells in mudflats at Heavy Reach.
Other observations	Portsmouth Harbour is a tidal inlet comprising a network of navigable channels, tidal creeks and lagoons. Extensive mudflats and saltmarshes in the upper reaches. Near the mouth, there are extensive developed/urbanised areas with naval dockyards and military establishments, ferry terminals and commercial docks.

Figure 4. Sites where surface water samples were collected during the shoreline surveys. A: River Wallington at North Fareham/Spurlings Farm; B: Outfall adj. Cams Hall South Park golf course; C: River Wallington at Wallington Bridge (A27); D: Town Quay Upper Wharf/Fareham CSO; E: Salterns

Lane adj West End STW; F: unidentified discharge at Fleetlands Creek.

G

H

I

J

Figure 4. Sites where surface water samples were collected during the boat/shoreline surveys (cont.). G: Fareham Lake - Peewit Island (designated shellfish water monitoring point); H: Portchester Lake (designated shellfish water monitoring point); I: Fountain Lake near Continental Ferry terminal.

The results of the coastal survey are given in Table 5 below.

Table 5. Bacteriological concentrations in surface water and shellfish samples collected during the boat/shoreline surveys.

Figure 1 ID	Date	Time	Sampling location	NGR Easting	Northing	Salinity	FC (confirmed)[a] (No $100g^{-1}$)	TC (presumptive)[b] (No $100ml^{-1}$)	FC (presumptive)[b] (No $100ml^{-1}$)	FS (presumptive)[b] (No $100ml^{-1}$)	MST filtration (code)
1194035	07/06/11	05:43	River Wallington at North Fareham/Spurlings Farm	458659	107929	-	-	1000	654	148	2
1194036	07/06/11	07:15	Outfall adj. Cams Hall South Park golf course	458131	105530	26.48	-	<10	<2	<2	2
1194037	07/06/11	07:39	River Wallington at Wallington Bridge (A27)	458712	106239	10.83	-	2200	462	186	2
1194038	07/06/11	08:03	Town Quay Upper Wharf/Fareham CSO?	457993	105910	3.62	-	>100,000	>100,000	34,000	2
1194039	07/06/11	08:25	Salters Lane adjacent West End STW	458104	105202	4.97	-	>100,000	97,000	17,000	2
1194040	07/06/11	08:42	Tichbourne Way PS/Brewers Lane Gosport CSO	457973	104645	12.19	-	10,000	2,520	731	2
1194041	07/06/11	09:15	Creek near Fleetlands/Foxbury Point	458890	104366	0.45	-	86,000	100,000	4,000	2
1194045	07/06/11	10:30	Cockles (*C. edule*) at Peewit Island (n=31)	460414	104278	-	1,300	-	-	-	-
1194042	07/06/11	10:54	Seawater near cockle sample at Peewit Island	460420	104281	-	-	<10	6	10	2
1194043	07/06/11	11:09	Seawater near Portchester Castle	462522	104266	-	-	<10	<2	<2	2
1194046	07/06/11	11:10	Cockles (*C. edule*) at Portchester Castle (n=50)	462522	104266	-	750	-	-	-	-
1194044	07/06/11	11:30	Seawater sample near Continental Ferry terminal	463923	102011	-	-	<10	11	<2	2
1194123	08/06/11	09:15	Cockles (*C. edule*) at upper Wallington Estuary (n=42)	458590	105951	-	470	-	-	-	-
1194124	08/06/11	10:15	Cockles (*C. edule*) South of Cams Hall Golf Course	459037	104965	-	250	-	-	-	-
1194125	08/06/11	11:11	Cockles (*C. edule*) adj. Grove Avenue (n>40)	461383	104590	-	-	-	-	-	-
1194126	08/06/11	11:34	Cockles (*C. edule*) Port Solent (very small sizes<1cm)	462868	105604	-	500	-	-	-	-

FC – faecal coliforms; TC – total coliforms; FS – faecal streptococci. a – enumerated using the Most Probable Number method. b – enumerated using the membrane filtration method. MST code 2 – sample collected and stored. Analysis not undertaken.

4 Conclusions

- The most significant point sources of contamination observed were Fareham CSO and Salterns Lane CSO and, to a lesser extent, Tichbourne Way PS/Brewers Lane Gosport CSO. All of these discharge directly to the shellfish water. The high concentrations of faecal indicators detected at the time of the survey are consistent with crude or primary treated effluent. It is likely that there may be households misconnecting their waste appliances to the surface water system.

- The location of three piped discharges observed at the time of the coastal survey (West End adj. STW, Cams Hall, and Fleetlands Creek) requires further investigation.

- The River Wallington represents a significant source of microbiological contamination to the shellfish water. The concentration of faecal coliforms in the sample collected downstream of the urban area of Wallington was lower than that in the sample upstream of North Fareham. More targeted studies are required to understand the relative contributions of urban and agricultural runoff to the overall load of contamination from the river Wallington.

- Water in the creek near Fleetlands/Foxbury Point was found to be highly contaminated. However, the source of this contamination was not identified at the time of the survey. Further investigations are required to identify the origin of this contamination.

- Levels of faecal coliforms in seawater samples collected in Peewit Island, Portschester Castle and near the Ferry Terminal were low indicating good water quality in the harbour at the time of the survey.

- Levels of faecal coliforms in cockles collected in both surveys were consistent with class B under the hygiene controls.

- Patches of commercially sized cockles were observed in Peewit Island and Portschester Castle in sufficient numbers for sampling in the proximity of the designated sampling points. Larger cockles from previous year classes were considerably less abundant. Alternatively, Manila clams could be used as sentinel species should cockle densities decrease significantly in the future, particularly in Portchester Castle. All of the areas inspected are easily accessible and therefore regular sampling is possible.

5 Shellfish hygiene monitoring

Native oysters have been sampled on a monthly basis from designated monitoring points in Portsmouth Harbour for the purposes of classifying shellfish production areas since the implementation of hygiene controls in 1991. Monthly *E. coli* results in oysters from Peewit Island and Portchester Lake for the period January 2000–May 2011 were used for the purposes of this study. Summary statistics indicate that there are no substantial differences between the two sites (Table 6). No significant (ANOVA; p<0.05; <1$\log_{10}$ between most contaminated and least contaminated months) differences were found in the levels of contamination between months/seasons.

Table 6. Summary statistics of levels of *E. coli* in oysters from Portsmouth Harbour.

Bed name	Species	Total number of samples	MPN *E. coli*/100g					
			Number of samples >230	Number of samples >4,600	Minimum	Maximum	Median	Geometric mean
Peewit Island	*O. edulis*	133	97	7	<20	54,000	220	539
Portchester Lake	*O. edulis*	134	104	6	40	16,000	500	583

Data period: January 2000–May 2011.

6 Relationships between *E. coli* levels in oysters and rainfall

The relationship between the levels of *E. coli* in oysters and rainfall were studied using the non-parametric Spearman's rank correlation coefficient. Statistically significant positive correlations were obtained between daily rainfall and *E. coli* levels in oysters from Peewit Island (2–5 days prior to sampling) and oysters from Portchester Lake (2–3 days prior to sampling) (Table 7). The strongest association between variables was obtained when rainfall fell 2 days before shellfish sampling. Significant positive relationships were also consistently observed between levels of the microbial indicator and cumulative rainfall during the week prior to sampling.

Figure 5 shows that although there is a general increasing trend in *E. coli* levels with rainfall, a significant proportion of class B (230<MPN *E.coli*<4,600) results were detected under dry weather or levels of rainfall below the average for the catchment (2.2mm).

Table 7. Results of correlation analysis (Spearman's rho; *p*≥0.230) between *E. coli* levels in shellfish flesh and daily/cumulative rainfall (World's End; SU62901180).

	n=73	Shellfish bed name (species)	
		Peewit Island (*O. edulis*) - B020B	Portchester Lake (*O. edulis*) - B020C
Total daily rainfall			
1 day		0.206	0.096
2 days		0.356*	0.342*
3 days		0.338*	0.314*
4 days		0.234*	0.174
5 days		0.261*	0.129
6 days		0.184	0.152
7 days		0.168	0.158
Cumulative rainfall	73		
2 days		0.296*	0.327*
3 days		0.339*	0.376*
4 days		0.387*	0.364*
5 days		0.414*	0.332*
6 days		0.439*	0.351*
7 days		0.462*	0.335*

* Significant at 95% confidence level. n=number of paired results. *E. coli* values <20 E. coli/100g were assigned values of 10 *E. coli*/100g. Data period: 01/01/2005–17/10/2011.

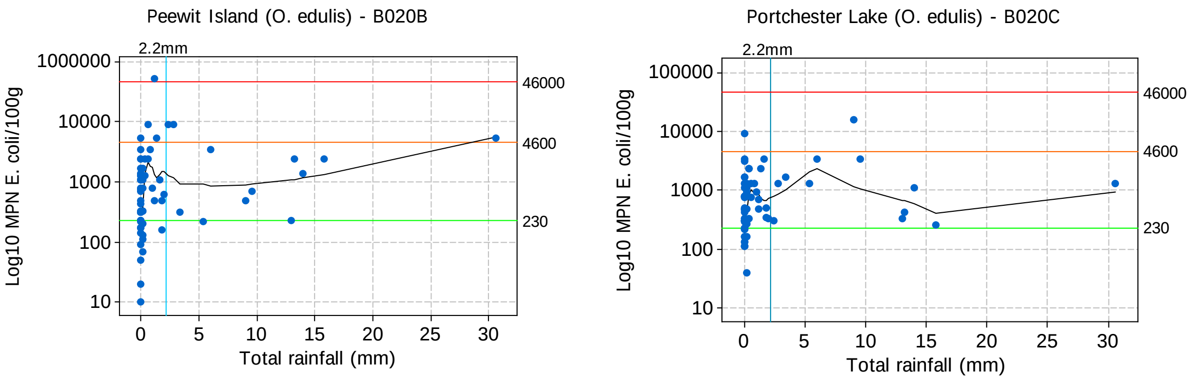


Figure 5. Scatterplot of *E. coli* levels in native oysters from Peewith Island and Portchester Lake and total rainfall (2 days before sampling). Blue reference line indicates average rainfall for the monitoring period. Green, orange and red lines indicate shellfish hygiene classification thresholds.

These results indicate that episodes of poor microbial quality of shellfish in Portsmouth Harbour are governed by rainfall events. Such rainfall events would be associated with the operation of rainfall-dependent sewage discharges and direct land runoff into the harbour.

7 Relationships between *E. coli* levels in oysters and tidal stage

Portsmouth Harbour is a tidal inlet characterised by a relatively narrow entrance which is constrained by a series of groynes and sea defences. It is an ebb dominant and well mixed system (Futurecoast, 2002). The inner harbour has depths of 1–3m over much of the shallow subtidal zone. The upper reaches of the harbour where commercial shellfish beds are established are fairly dendritic and shallow. Much of these areas are sandflats and mudflats exposed at low water. The maximum water depths within the boundaries of the shellfish water are 12m relative to Chart Datum in the middle of Portchester Lake (Imray, Laurie & Wilson Ltd., 2008).

Most of the inner harbour is protected from wave action (Lavender, 2010). Tidally-driven processes interacting with sandbanks and mudflats were therefore considered to be the dominant mechanism of transport of contamination impacting upon the shellfish water.

Tidal currents within the harbour are relatively complex due to the constricted harbour entrances, often with rapidly changing tidal range, extended high water and complex flow patterns in the lower harbour and around the headlands (Lavender, 2010).

It is assumed that the flood tide will convey contamination from pollution sources situated in Gosport and the City of Portsmouth, from where the main flows would split into two streams until it reaches the fisheries in Fareham Lake and Portchester Lake. The ebb tide will convey much of the contamination from the upper catchment and from the urban areas of Portchester and Fareham.

Circular statistics were used to understand whether tidally-driven mechanisms would exert a significant effect on the quality of shellfish flesh. Figure 6 shows polar plots of *E. coli* levels in oysters against tidal state on the high-low cycle. There is a good distribution of *E. coli* results over the tidal cycle. No significant differences were found between the levels of contamination in oysters from

Peewit Island (circular linear correlation *r*=0.03; p=0.892) and Portchester Lake (circular linear correlation *r*=0.18; p=0.014) and tidal stage.

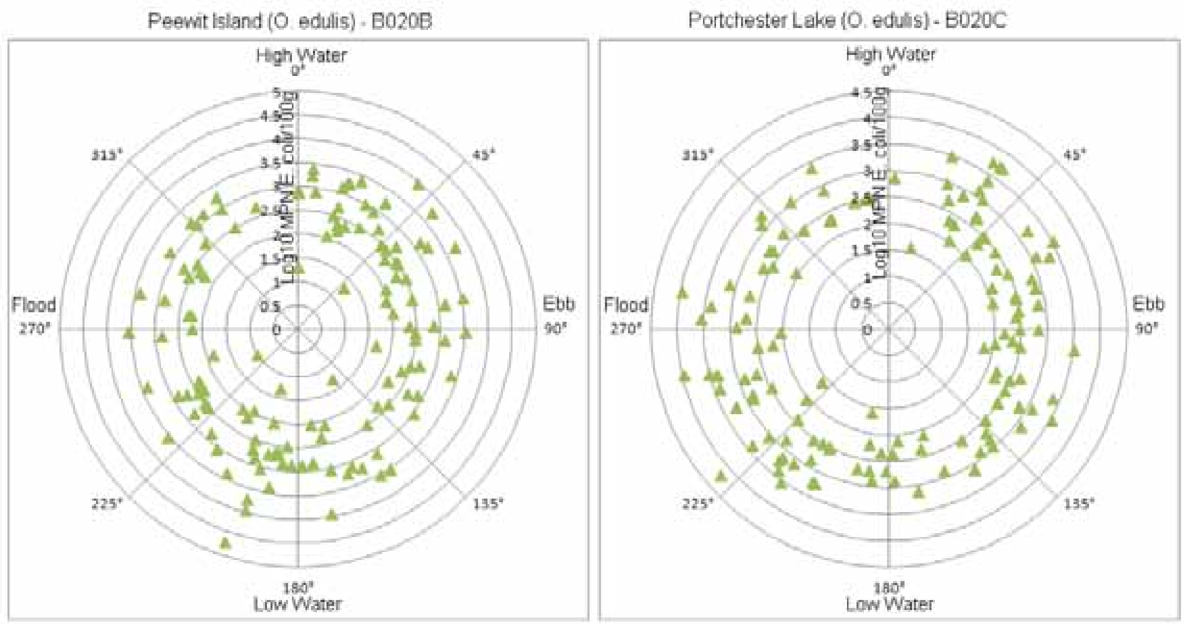


Figure 6. Polar plots of *E. coli* levels in native oysters against tidal state in Portsmouth Harbour.

The results indicate that the shellfish water is at risk of being significantly impacted by microbiological contamination at any given stage of the tidal cycle. Due to the expected bi-directional impacts, further improvements to intermittent discharges in Portsmouth and Gosport are likely to promote the potential for dilution in the deeper areas of the lower harbour and improve the overall quality of the shellfish water.

8 Recommendations

Rainfall-dependent discharges have a significant impact upon the Portsmouth Harbour shellfish water. It is recommended that improvements are made to these discharges, namely those associated with urban areas Portsmouth, Gosport, Portchester and Fareham, where the impermeable nature of the catchment which promotes rapid (<24h) response of watercourses to rainfall events. Improvements to these discharges are likely to have the greatest impact towards improving water quality and ensuring compliance with the SWD guideline standard. This assumption is supported by sanitary profiling work recently undertaken for a nearby shellfish water catchment (Chichester Harbour) with similar land uses (see Crowther et al., 2011). The improvements could involve for example the transference of these discharges to Budds Farm STW or Peel Common – which will receive UV disinfection by 2015 – and/or improving the level of treatment in CSOs.

Due to the underlying geology in the upper catchment (mostly chalk), rainfall tends to soak into the ground and recharge groundwater stores rather than rapidly entering the river system as runoff (Environment Agency, 2007). Therefore, runoff from agricultural land is likely to be less significant than point-source pollution. However, at present there is insufficient information on loads of microbiological contaminants derived from catchment sources and a more detailed programme of monitoring – which is outside the scope of this work – would need to be undertaken to accurately determine the contribution from sewerage-related and agricultural sources of pollution.

9 References

Acornley, R.M., Morgan, O.C., Campos, C.J.A., Kershaw, S. 2010. Temporal trends in the microbial quality of shellfish from UK production areas. Cefas report to Defra, Project WT1001 – Factors affecting the microbial quality of shellfish.

Cefas, 2011. Designated bivalve mollusc production areas in England and Wales. Available at: http://www.food.gov.uk/multimedia/pdfs/enforcement/shellclassew2011112.pdf.

Crowther, J., Kay, D., Campos, C.J.A., Morgan, O.C. 2011. Sanitary profiles of selected shellfish water catchments pre- and post-improvements in sewerage infrastructure. Cefas and CREH report to Defra, Project WT1001 – Factors affecting the microbial quality of shellfish.

Environment Agency, 2007. South East Hampshire Catchment Flood Management Plan, version 3.

Environment Agency, 2009. Directive (2006/113/EC) on the quality required of shellfish waters. Article 5 programme: Portsmouth Harbour. Unpublished report.

European Communities, 2004. Regulation (EC) No 854/2004 of the European parliament and of the Council of 29 April 2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption. *Official Journal of the European Union* L226, 25.6.2004: 83–127.

European Communities, 2006. Directive 2006/113/EC of the European Parliament and of the Council of 12 December 2006 on the quality required of shellfish waters (codified version). *Official Journal of the European Union*, 27/12/2006, L376: 14–20.

Futurecoast, 2002. Defra, 3CD set.

Imray, Laurie & Wilson Ltd., 2008. Admiralty Chart 2200.5, Portsmouth Harbour and Approaches.

Kay, D., Crowther, J., Stapleton, C.M., Wyer, M.D., Fewtrell, L., Edwards, A., Francis, C.A., McDonald, A.T., Watkins, J., Wilkinson, J. 2008. Faecal indicator organism concentrations in sewage and treated effluents. *Water Research* 42: 442–454.

Lavender, J. 2010. HMS Bristol Dredging Programme: non-technical summary. Report 9W1867/R/303950/Lond from Royal Haskoning UK Ltd. to Portsmouth Commercial Port.

Cefas

About us

Cefas is a multi-disciplinary scientific research and consultancy centre providing a comprehensive range of services in fisheries management, environmental monitoring and assessment, and aquaculture to a large number of clients worldwide.

We have more than 500 staff based in 2 laboratories, our own ocean-going research vessel, and over 100 years of fisheries experience.

We have a long and successful track record in delivering high-quality services to clients in a confidential and impartial manner.
(www.cefas.defra.gov.uk)

Cefas Technology Limited (CTL) is a wholly owned subsidiary of Cefas specialising in the application of Cefas technology to specific customer needs in a cost-effective and focussed manner.

CTL systems and services are developed by teams that are experienced in fisheries, environmental management and aquaculture, and in working closely with clients to ensure that their needs are fully met.
(www.cefastechnology.co.uk)

Customer focus

With our unique facilities and our breadth of expertise in environmental and fisheries management, we can rapidly put together a multi-disciplinary team of experienced specialists, fully supported by our comprehensive in-house resources.

Our existing customers are drawn from a broad spectrum with wide ranging interests. Clients include:

- international and UK government departments
- the European Commission
- the World Bank
- Food and Agriculture Organisation of the United Nations (FAO)
- oil, water, chemical, pharmaceutical, agro-chemical, aggregate and marine industries
- non-governmental and environmental organisations
- regulators and enforcement agencies
- local authorities and other public bodies

We also work successfully in partnership with other organisations, operate in international consortia and have several joint ventures commercialising our intellectual property

Head office
Centre for Environment, Fisheries & Aquaculture Science
Pakefield Road, Lowestoft,
Suffolk NR33 0HT UK

Tel +44 (0) 1502 56 2244
Fax +44 (0) 1502 51 3865

Web www.cefas.defra.gov.uk

Centre for Environment, Fisheries & Aquaculture Science
Barrack Road, The Nothe
Weymouth, DT4 8UB

Tel +44 (0) 1305 206600
Fax +44 (0) 1305 206601

printed on paper made from a minimum 75% de-inked post-consumer waste