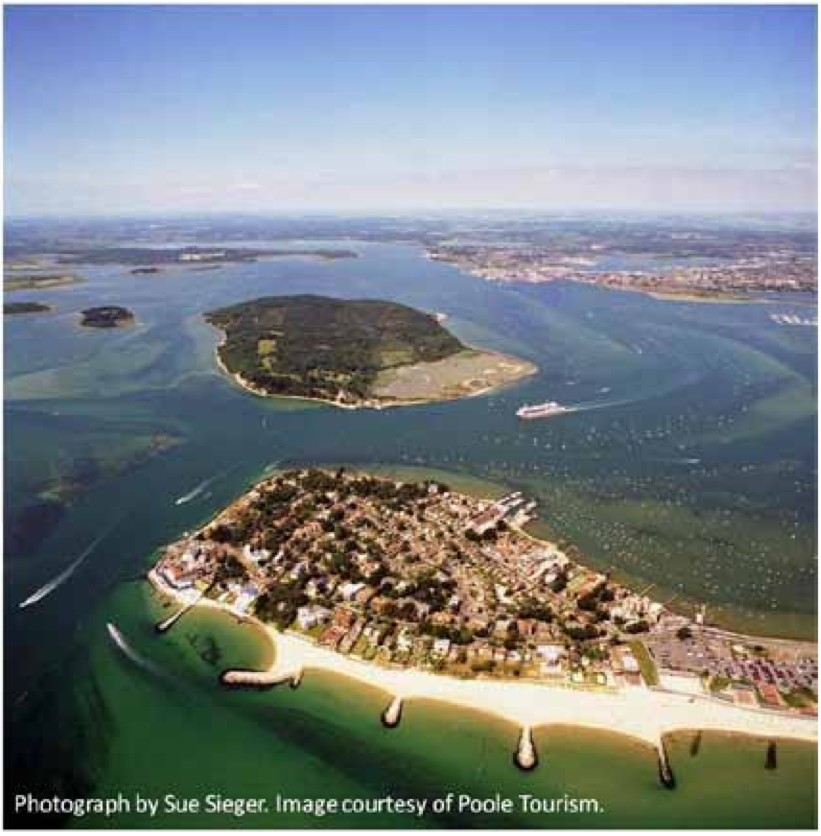
EC Regulation 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SANITARY SURVEY

Poole Harbour



Photograph by Sue Sieger. Image courtesy of Poole Tourism.

2009

(Sampling Plan updated 2012)

Cover photo: Photograph by Sue Sieger. Image courtesy of Poole Tourism.

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

DISSEMINATION: Food Standards Agency, Poole Borough Council, Environment Agency, Southern Sea Fisheries Committee.

CONTENTS

EXECUTIVE SUMMARY

Under EC Regulation 854/2004 there is a requirement for competent authorities intending to classify bivalve mollusc production and relaying areas to undertake a number of tasks collectively known (in England and Wales) as ‘sanitary surveys’. The main purpose of these surveys is to inform the sampling plans for the microbiological monitoring programme and classification of production areas.

This report documents information arising from a sanitary survey of the Poole Harbour production area, England. The sanitary survey was prompted by an application for classification of the harbour for the harvesting of native clams (*Tapes decussatus*).

Poole Harbour is a large (c. 38km^2) estuary located on the south coast of England. The estuary is shallow and the tidal regime is characterised by an unusual double high water. The north side of the harbour is urbanised, whereas the south side of the harbour is rural in nature. The estuary is a very important commercial shellfishery, containing wild and farmed beds for the production of oysters, mussels, cockles and clams.

The continuous sewage effluent discharges to the harbour from the large sewage treatment works at Poole, Lytchett Minster and Wareham STW receive year-round UV disinfection. This will inevitably reduce the impact of these discharges on shellfisheries in the harbour. There are a number of smaller sewage treatment works effluent discharges and storm and emergency overflows to the harbour that may have localised impacts.

The main freshwater inputs to the harbour are from the Rivers Frome and Piddle, with smaller inputs from the Corfe River, Sherford River and several other streams. These rivers are likely to be more significant sources of contamination than the sewage effluent discharges to the harbour.

Birds and other wildlife may be a significant source of microbiological contamination in the harbour. The estuary supports very large numbers of wintering waders and wildfowl and there is a large colony of gulls on the saltmarsh islands in the Wareham Channel. There is also a significant population of sika deer in the south and west of the harbour.

Analysis of recent microbiological data for the production area indicates that microbiological water quality in the harbour is generally good (typically class B), although high levels of contamination have been recorded in the Wareham Channel and Holes Bay. Seasonal variation in levels of contamination is evident at several sites (but not all), with the highest levels of contamination in the winter.

A sampling plan showing classification zones and representative monitoring points is presented. Following feedback from local enforcement authority Poole Borough Council on difficulties in access and enforcement, the sampling plan was revised in February 2012. Following rationalisation of monitoring and inclusion of new sampling points are proposed at Whitley Lake and Brands Bay. The recommended total number of sampling points has not increased and remains at nine.

1 INTRODUCTION

Filter-feeding bivalve shellfish can accumulate bacterial and viral pathogens from sewage-contaminated waters. The consumption of raw or insufficiently cooked shellfish harvested from such waters can cause illness and lead to outbreaks of infectious disease (e.g. Norovirus-associated gastroenteritis, Hepatitis A and Salmonellosis). In order to protect public health, under EC Regulation 854/2004[1], shellfish harvesting and relaying areas are classified on the basis of monitoring of levels of faecal indicator organisms (*Escherichia coli* in the EU) in shellfish. This classification determines the level of treatment required (e.g. purification, relaying or cooking) before human consumption, or may prohibit harvesting.

EC Regulation 854/2004, states that 'if the competent authority decides in principle to classify a production or relay area it must:

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

ii) 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 treatments, etc.;

iii) determine the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal cycle in the production area; and

iv) 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'.

In England and Wales these activities are collectively known as a 'sanitary survey' (Cefas, 2007). The Centre for Environment Fisheries and Aquaculture Science (Cefas) is performing sanitary surveys for new bivalve mollusc production areas (BMPAs) in England and Wales on behalf of the Food Standards Agency (FSA). This report documents information arising from a sanitary survey relevant to the Poole Harbour BMPA, England. The sanitary survey was prompted by an application for classification of the harbour for the harvesting of native clams (*Tapes decussatus*) in areas that are already classified for the harvesting of Manila clams (*Tapes philippinarum*). The harbour also contains existing classified zones for the harvesting of native oysters (*Ostrea edulis*), Pacific oysters (*Crassostrea gigas*), mussels (*Mytilus* spp.) and cockles (*Cerastoderma edule*).

This report is restricted to the establishment of a sampling plan for the Poole Harbour BMPA and current arrangements for sampling in the wider 'Poole' production area (i.e. within Poole Bay) have not been reviewed.

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[1] EC Regulation 854/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific rules for the organization of official controls on products of animal origin intended for human consumption.

2 SITE DESCRIPTION

2.1 General description of the production area

Poole Harbour is a bar built estuary located on the Dorset coast in the south of England (Figure 2.1). The estuary occupies an area of approximately 38km^2 at high water springs, of which 54% is intertidal. The highly indented shoreline exceeds 100km and there are five main islands (Brownsea, Furzey, Green, Round and Long) and a single entrance. Water depths throughout the estuary are generally shallow (less than 2m above chart datum). The estuary is microtidal, with a tidal range of 1.8m on springs and 0.6m on neaps at Poole Quay. The tidal regime is characterised by a prolonged “double” high water that can sustain water levels above mean tide level for around 16 out of every 24 hours (Humphreys, 2005).

The main freshwater inputs to Poole Harbour are the Rivers Frome and Piddle which combine to form a mean discharge of around 8.8m^{3}s^{-1} at the western end of the harbour (CEH, 2009). The harbour also receives much smaller freshwater inputs from the Corfe River, Sherford River and a number of other small streams.

There is a marked contrast in land use between the north and south shores of the harbour (Figure 2.2), with urban and industrial development in Poole to the north and natural and rural areas (forest, heathland and pasture) to the south. Poole is a commercial port handling cross-channel passenger ferries (Ro/Ro), freight and conventional bulk cargo. The port is also home to a fleet of around 90 registered fishing boats, of which 30 fish within the harbour itself (Walmsley and Pawson, 2007). The harbour is very popular for recreational watersports and there are a number of yacht marinas and numerous yacht moorings in the harbour.

Since 1999, Poole Harbour has been designated as a Special Protection Area (SPA) under the EC Birds Directive on the basis of its internationally important populations of birds (Langston *et al*., 2003). The harbour also contains areas designated under the EC Shellfish Waters and Bathing Waters Directives.

The estuary has a catchment area of around 800km^2. Approximately 70% of the estuary catchment is farmed, with cereal, dairy and cattle and sheep farming being predominant (Environment Agency, 1999). The total human population of the catchment is approximately 161,000, with major population centres at Poole (population 138,300), Dorchester (population 16,190) and Wareham (population 5,670) (2001 census figures, Dorset County Council, 2005).

2.2 Climate

The region is far from the paths of most Atlantic depressions, with their associated cloud, wind and rain, so the climate is relatively quiescent (Met Office, 2009). Monthly climate averages for the Met Office station at Hurn (Bournemouth Airport) are given in Table 2.1. Hurn is situated approximately 10km north east of Poole Harbour.

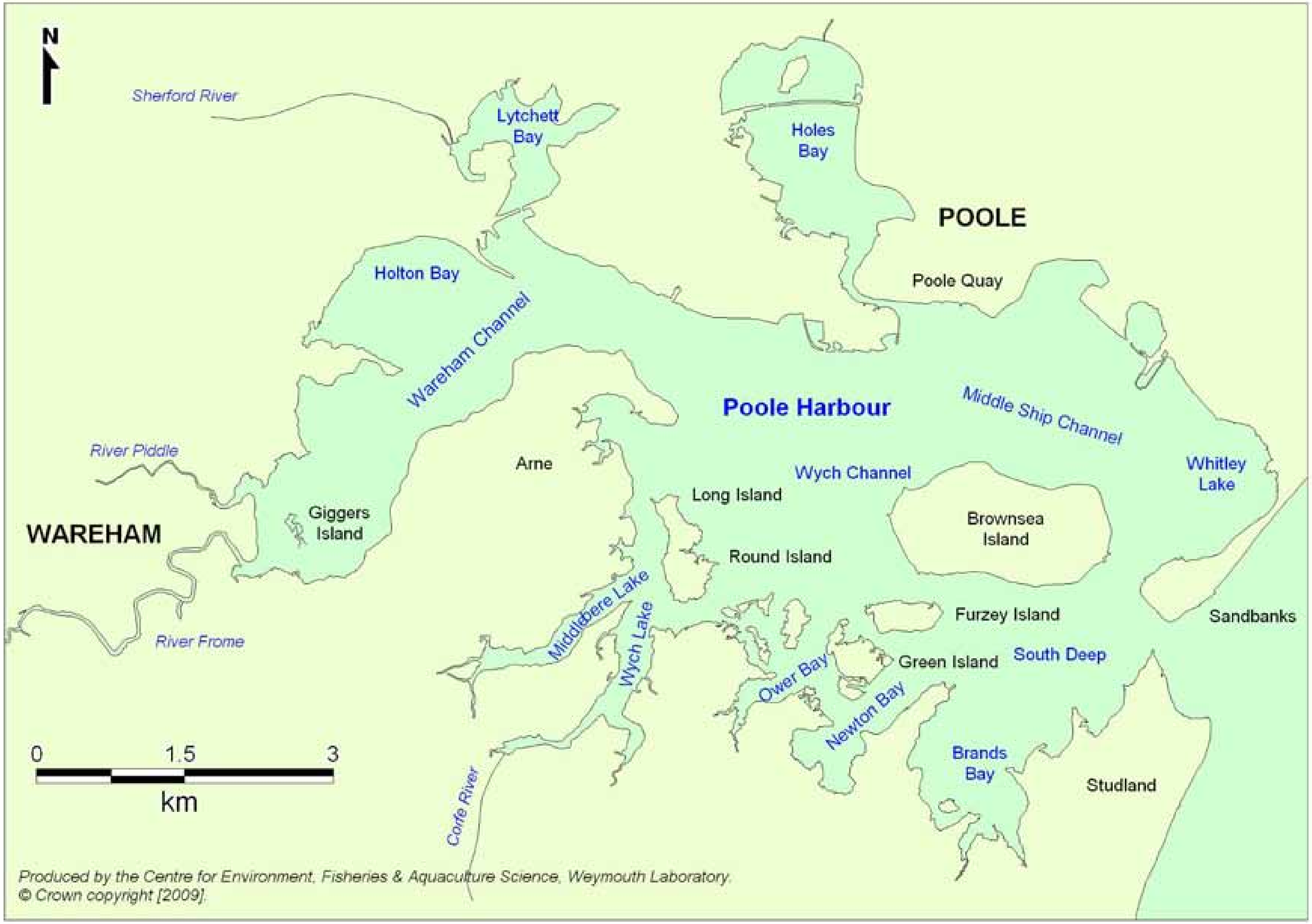

Figure 2.1 *Location map of Poole Harbour*

Figure 2.2 *Landsat 7 pseudocolor image of Poole Harbour. Note contrast in land use between north and south shores. Image from: http://onearth.jpl.nasa.gov/.*

Table 2.1 *Climate averages for Hurn, 1999-2008 (Data source Met Office)*

Month	Rainfall (mm)	Temperature (°C) minimum	Temperature (°C) maximum	Sunshine (hours)
Jan	85	2.2	9.3	71
Feb	61	1.8	9.4	90
Mar	60	2.9	11.4	123
Apr	60	4.6	14.2	181
May	62	7.9	17.3	203
Jun	46	10.3	20.0	229
Jul	59	12.1	22.0	224
Aug	53	12.2	21.9	204
Sep	60	10.1	20.0	164
Oct	110	7.5	15.7	110
Nov	111	3.9	11.8	82
Dec	103	1.9	9.0	65

Rainfall at Hurn averages around 870mm per year. Rainfall is generally well-distributed throughout the year with a maximum in autumn/early winter. Rainfall related sources of contamination (such as storm overflows) are anticipated to be maximal during this period.

A wind rose showing the percentage of wind in each sector derived from representative wind conditions for Poole Harbour in Halcrow Maritime (1999) is presented in Figure 2.3. The prevailing wind direction is south westerly.

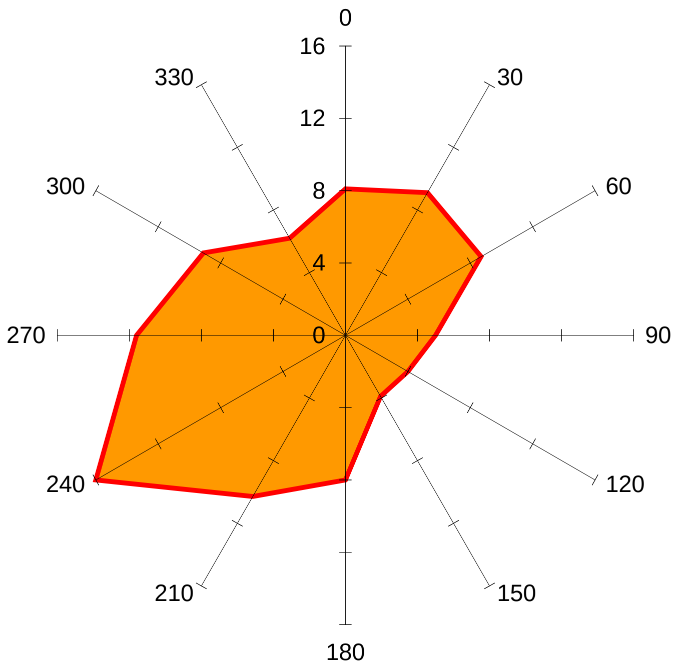

Figure 2.3 *Wind rose for Poole Harbour (data source Halcrow Maritime, 1999)*

2.3 Hydrodynamics

Typical spring and neap tidal curves for Poole Harbour are given in Figure 2.4. It can be seen from the graph that on spring tides the first high water is higher than the second whilst on neap tides the reverse is true.

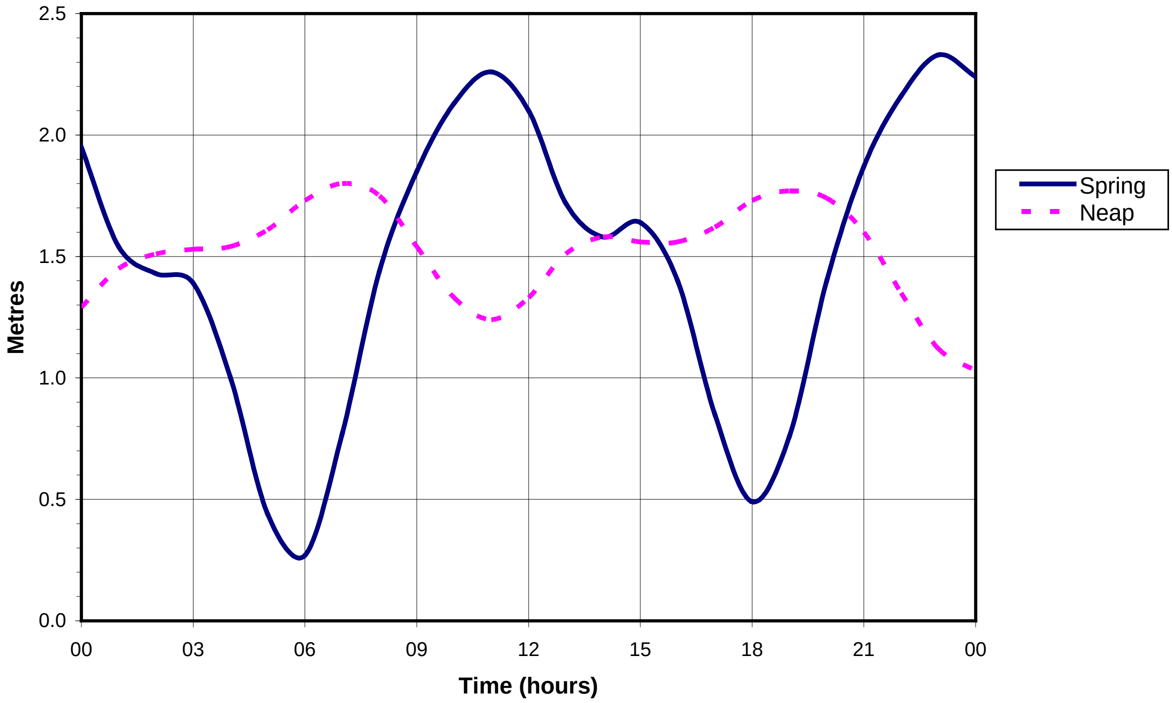

Figure 2.4 *Spring and neap tidal curves for Poole Quay (predictions from POLTIPS)*

There have been a number of numerical modelling studies of tidal currents within Poole Harbour. These include those of Falconer (1983, 1984) and more recent studies by HR Wallingford (1999, 2004). Peak spring ebb and flood flow tidal flow vectors taken from Royal Haskoning (2004) are shown in Figure 2.5. The strongest tidal currents (around 2.0 m/s) occur in the entrance to the harbour. Tidal flows around most of the periphery of the harbour, including Holes Bay and Lytchett Bay, are generally low. Strong currents are mainly limited to the main channel from the entrance to Town Quay, and the entrances to Holes Bay and Lytchett Bay. Maximal currents in the main channel are approximately 0.5 m/s.

Within the harbour the peak ebb flow generally occurs at or just before low water, when strong currents occur between Poole Town Quay and Sandbanks. The flood tide commences about an hour after low water with peak flood tidal currents occurring at about three hours after low water. The first high water occurs approximately six hours after low water and corresponds to virtually quiescent conditions. Tidal flows change direction at about seven hours after low water, but flow rates drop significantly at nine hours at the second high water. At ten hours after low water, a strong ebb flow has set in again, reaching peak current speeds at around low water (Halcrow Maritime, 1999).

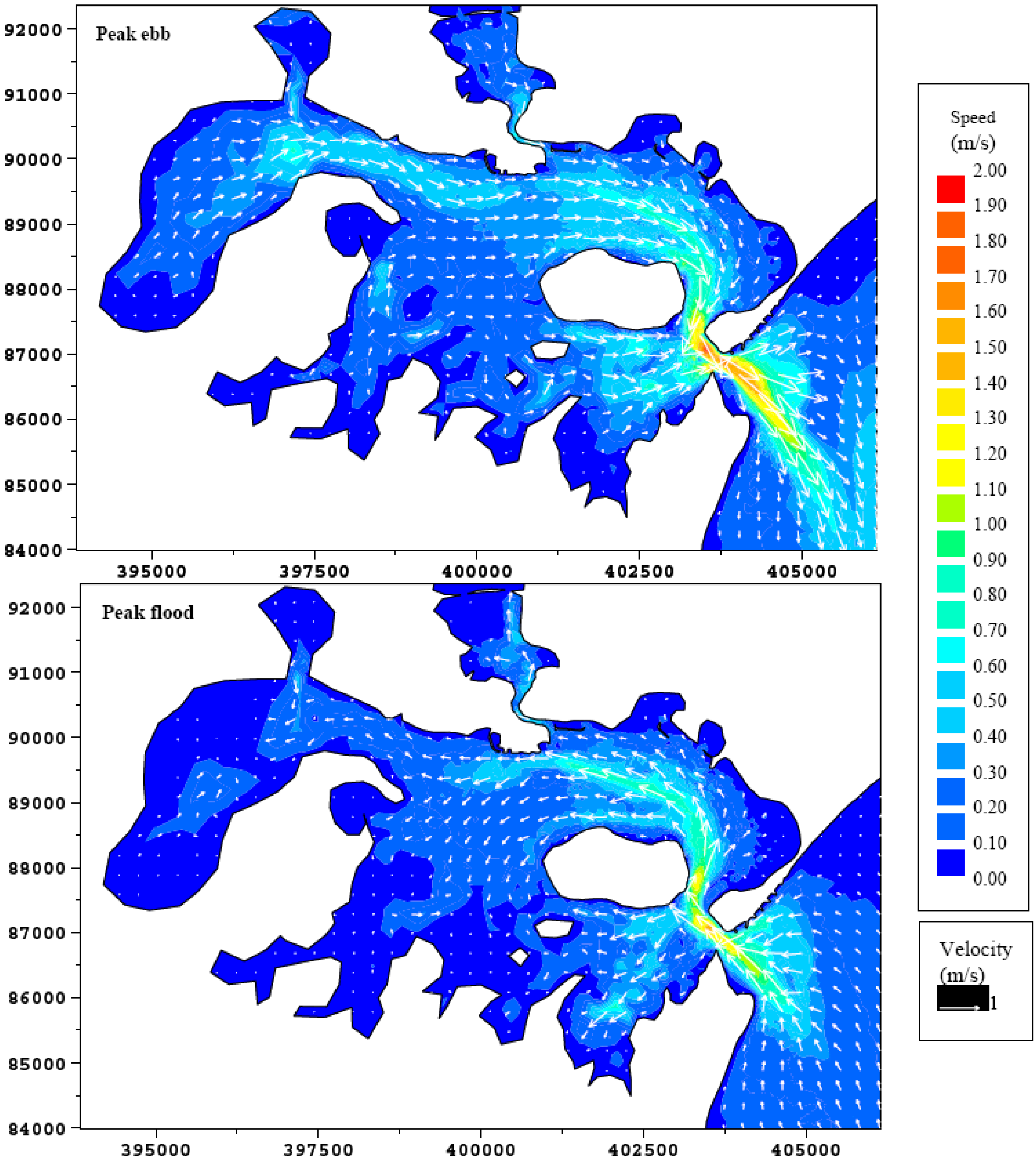

***Figure 2.5** Peak spring ebb and flood flow tidal flow vectors for Poole Harbour (reproduced from Royal Haskoning (2004) with permission of Poole Harbour Commissioners)*

A gradient in salinity is evident from the harbour entrance to the upper reaches, from higher to lower salinity, respectively (Humphreys, 2005). Salinity in the main body of the harbour is typically in the range 25 to 35 ppt. Much lower salinities (<15 ppt) have been observed in the Wareham Channel and the mouth of Lytchett Bay, particularly during periods of high river flow.

The main body of Poole Harbour is well mixed and more or less vertically homogenous with respect to salinity (Humphreys, 2005). In contrast, the Wareham Channel is partially mixed and vertical gradients in salinity can develop, with salinities at the bed being greater than those at the surface.

3 SHELLFISHERIES

Poole Harbour contains both natural and farmed shellfisheries for oysters, clams, cockles and mussels. Most of the shellfisheries in the harbour are regulated by Southern Sea Fisheries Committee (SSFC) under the Poole Harbour Fishery Order (Anon, 1996), which is a hybrid order combining a regulated and several fishery. The several fishery facilitates shellfish aquaculture within the harbour, whilst the regulated fishery covers most of the harbour and provides the regulatory framework for which commercial fisheries are managed (Jensen *et al*., 2005a). A map showing the location and extent of wild and farmed shellfish beds in the harbour that incorporates information recently provided by SSFC, is presented in Figure 3.4.

3.1 Aquaculture beds

The leased aquaculture beds cover an area of approximately 182ha. The main beds are located to the north and west of Brownsea Island, although there is also a designated relaying area for native oysters (*Ostrea edulis*) at South Deep to the south of Brownsea (Figure 3.4). Approximately 100 tonnes of seed cockle (*Cerastoderma edule*), 2 million individual Manila clams (*Tapes philippinarum*) and 2 million individual Pacific oysters (*Crassostrea gigas*) are laid on the beds each year, and approximately 800-1000 tonnes of seed mussel (*Mytilus edulis*) are grown in the beds at any one time. The total value of landings from these beds is in excess of £1 million per year (Jensen *et al*., 2005a). Shellfish are harvested from the leased aquaculture beds all year round.

Othniel Oysters Ltd is one of the largest operators in Poole Harbour, farming 51ha of the aquaculture beds. The company harvests clams, cockles, mussels and oysters, with up to 400 tons of Pacific oysters harvested per year. Because the beds rarely dry out, shellfish are harvested using a 'conveyor harvester' (Figure 3.1) that dislodges the shellfish from the bed sediment using water jets and then transports them into the boat via a stainless steel mesh belt (Figure 3.2). Up to 5 tons per hour can be harvested from well stocked grounds using this method.

Figure 3.1 *Conveyor harvester. Photo courtesy of Gary Wordsworth, Othniel Oysters Ltd.*

Figure 3.2 *Harvesting Pacific oysters in Poole Harbour on conveyor harvester. Photo courtesy of Gary Wordsworth, Othniel Oysters Ltd.*

3.2 Clam fishery

A highly valuable fishery for naturalised Manila clams (*Tapes philippinarum*) has developed within the harbour. Most of this fishery is regulated under the Poole Fishery Order by SSFC, who issue licences, although harvesting also occurs in areas (notably Brands Bay in the south east of the harbour) that are outside of the regulated fishery. The closed season for the regulated clam fishery is set by SSFC and can vary from year to year. The fishery is currently open from late October to early January. There is no closed season for clam harvesting in areas outside of the regulated fishery. Clams are harvested from the seabed at high tide during daylight hours by a pump scoop dredge that is towed behind a small (<10m) boat (Jensen *et al*., 2005a,b). Poaching of clams has been a major problem, as has illegal fishing in areas prohibited for shellfish production. It is estimated that around 600 tonnes of clams were harvested from the harbour in the 2003/2004 season by both licence holders and poachers (Royal Haskoning, 2004).

Native clams (*Tapes decussatus*) also occur within the harbour although there is no current classification for production of this species outside of the aquaculture beds. Native clams generally command a higher price than Manila clams and classification for harvesting of this species has been requested. Both Manila and native clams are found in the intertidal areas of the west and south of the harbour (Figure 3.4), although fishing activity is largely concentrated in the north part of the Wareham Channel and between Round Island and Green Island in the south of the harbour (Royal Haskoning, 2004).

3.3 Cockle fishery

Cockles are patchily distributed throughout the intertidal areas of the harbour (Figure 3.4). Harvesting activity is largely concentrated in the south of the harbour and at Whitley Lake in the north-east (Royal Haskoning, 2004). Most commercial cockle fishermen use a pump-dredge trailed behind a small boat (Figure 3.3), although there is also a traditional fishery in the sandy littoral areas of the harbour such as Whitley Lake where cockles are harvested by hand rake (Royal Haskoning, 2004; Jensen *et al*., 2005a). The harvesting season for wild cockles extends from 1st May to 31 January.

Figure 3.3 *Cockle harvesting using pump dredge in Poole Harbour. Photo © Cefas*

Harvesting seasons within the harbour are summarised in Table 3.1 below.

Table 3.1 *Shellfish harvesting seasons in Poole Harbour*

	J	F	M	A	M	J	J	A	S	O	N	D
Aquaculture beds												
Mussels	■	■	■	■	■	■	■	■	■	■	■	■
Clams	■	■	■	■	■	■	■	■	■	■	■	■
Cockles	■	■	■	■	■	■	■	■	■	■	■	■
Native oysters	■	■	■	■	■	■	■	■	■	■	■	■
Pacific oysters	■	■	■	■	■	■	■	■	■	■	■	■
Wild beds												
Cockles	■				■	■	■	■	■	■	■	■
Clams (regulated)[1]	■									■	■	■
Clams (open)[2]	■	■	■	■	■	■	■	■	■	■	■	■

1. Harvesting within regulated fishery (can vary from year to year)
2. Harvesting outside of regulated fishery

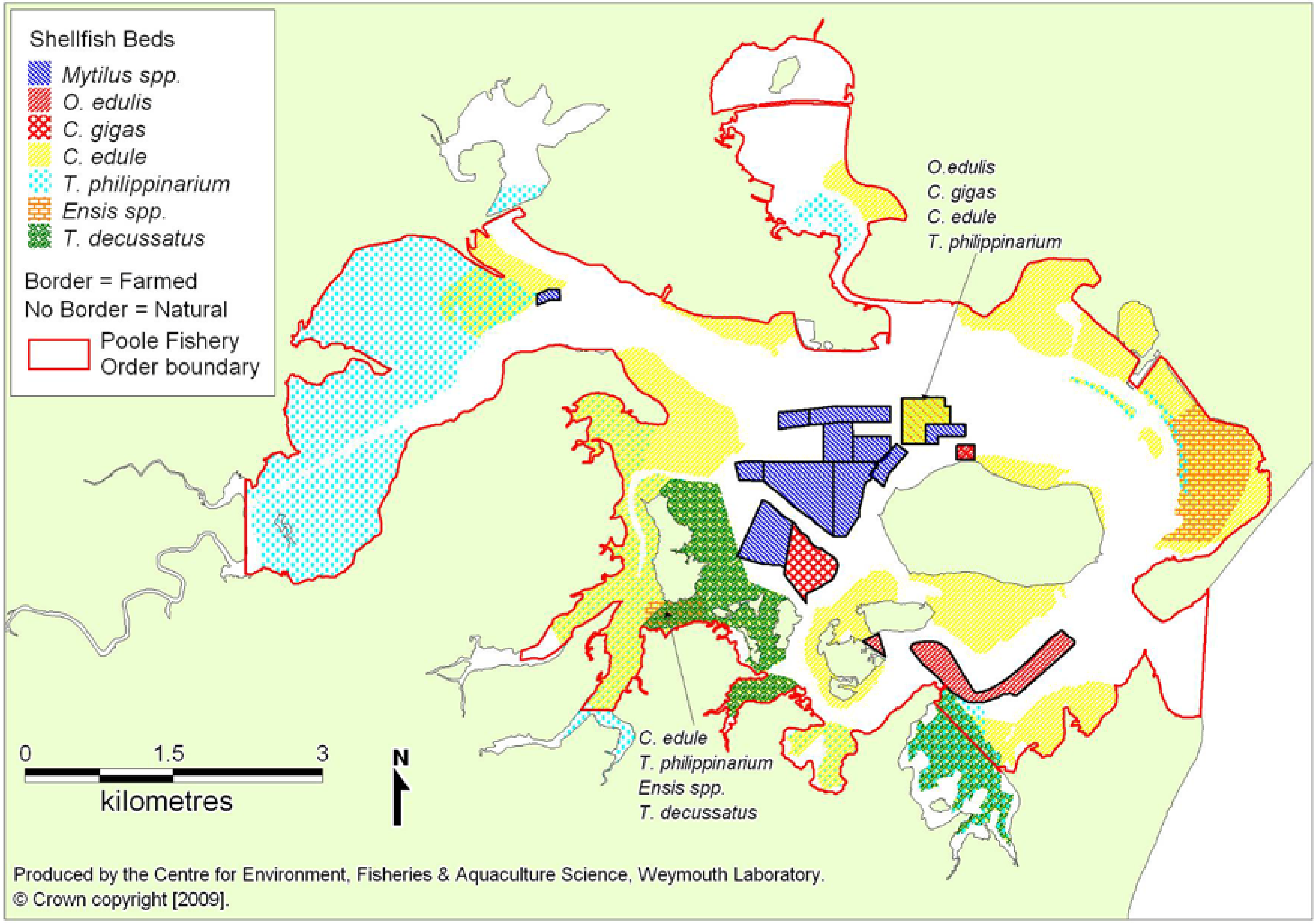

Figure 3.4 *Natural and farmed shellfish beds in Poole Harbour. Information on current shellfish distribution provided by the SSFC.*

4 SOURCES OF MICROBIOLOGICAL POLLUTION

4.1 Sewage discharges

Point source discharges to shellfisheries from municipal sewage treatment works (STWs) represent the most significant risk to human health because of the diverse contributing population and large volume of effluent discharged (Garreis, 1994). Sewage treatment facilities for the Poole area are provided by Wessex Water Services Ltd. Details of continuous sewage discharges that have the potential to impact on levels of microbiological contamination in the production area are given in Table 4.1 and their locations are shown in the map in Figure 4.1.

Table 4.1 *Continuous sewage discharges with potential to impact on Poole Harbour production area*

STW name	NGR of outfall	DWF (m^3/day)	Treatment level
Poole STW	SZ 0071 9356	47,700	Tertiary (UV)
Wareham STW	SY 9364 8863	2,502	Tertiary (UV)
Lytchett Minster STW	SY 9682 9228	1,600	Tertiary (UV)
Corfe Castle STW	SY 9611 8314	370	Secondary
Studland STW	SZ 0235 8454	227	Secondary
Brownsea Island STW[a]	SZ 0270 8784	190 (Max.)	Secondary
Holton Heath STW	SY 9518 9062	182	Secondary

STW=sewage treatment works, DWF=consented dry weather flow, Max.= consented maximum flow, [a] Not water company owned

The largest continuous sewage discharge to Poole Harbour is from Poole STW. This STW serves a population equivalent of 162,000 (Wessex Water Services Ltd., 2009). The STW discharges into Holes Bay to the north of the harbour. Other major STW discharges are from Wareham, which discharges to the tidal reaches of the River Piddle, and Lytchett Minster that discharges to Lytchett Bay. The effluents from Poole, Wareham and Lytchett Minster STWs receive year-round UV disinfection in order to reduce the microbiological content of the effluent. The UV disinfection schemes were designed to reduce faecal coliform concentrations at the boundaries of designated Shellfish Waters in the harbour (Sherwin and Menhinick, 2001).

Wessex Water is required to monitor the bacteriological quality of the disinfected STW effluents in order to assess the efficacy of the UV disinfection process. A summary of faecal coliform data for the UV disinfected effluents from Poole, Wareham and Lytchett Minster STWs for the period 2003 to 2009 is presented in Table 4.2. The data indicate that the UV disinfection is highly effective in reducing faecal coliform concentrations of the effluent. The impact of these discharges on faecal indicator organisms in shellfisheries in the harbour is therefore expected to be negligible under normal operating conditions. However, given the size of the discharges from Poole, Lytchett Minster and Wareham STWs, a significant impact on levels of contamination of shellfisheries in the harbour would be anticipated in the event of a malfunction of the STW or failure of the UV disinfection systems.

Faecal coliform concentrations in the effluent from Poole STW have increased since 2006. The underlying cause of this deterioration in effluent quality is not known.

Table 4.2 *Summary of post disinfection faecal coliform data (no per 100ml) for STWs discharging to Poole Harbour, 2003 to 2009 (Data source Environment Agency).*

Year	No. samples	Geometric mean	Minimum	Maximum	%>100 per 100ml
Wareham STW					
2003	18	84	<10	560	50
2004	26	130	10	2,100	54
2005	26	120	<10	3,600	54
2006	26	110	<10	4,100	54
2007	27	110	<10	3,400	59
2008	25	100	<10	5,900	48
2009	15	290	<10	7,300	67
Grand Total	**163**	**120**	**<10**	**7,300**	**55**
Lytchett Minster STW					
2003	18	12	<10	250	11
2004	26	19	<10	370	23
2005	26	19	<10	460	15
2006	26	11	<10	290	4
2007	26	12	<10	530	4
2008	26	34	<10	1,400	27
2009	10	41	<10	2,900	30
Grand Total	**158**	**18**	**<10**	**2,900**	**15**
Poole STW					
2003	18	60	<10	380	17
2004	26	150	10	630	65
2005	26	80	<10	2,900	46
2006	26	180	<10	20,000	62
2007	26	580	30	9,000	85
2008	26	560	<10	7,500	88
2009	14	540	10	5,700	86
Grand Total	**162**	**210**	**<10**	**20,000**	**65**

Corfe Castle STW discharges treated sewage effluent to the Corfe River approximately 2.5km upstream of the tidal limit. Although this will contribute to the overall bacteriological load of the Corfe River, microbiological monitoring undertaken downstream of this discharge by the Environment Agency indicates that the river provides sufficient dilution of the effluent to minimise the impact of this discharge on shellfisheries in the harbour (See section 4.3).

Holton Heath STW discharges treated sewage effluent to a small stream that flows into the harbour in close proximity to the clam beds in the Wareham Channel. Microbiological monitoring of this stream by the Environment Agency has revealed high levels of faecal coliforms and suggests that the STW could have an impact on levels of contamination of shellfisheries in Holton Mere (See section 4.3). It is, however, likely that any impact would be localised given the low volume of discharge from the STW. The stream receiving the effluent from Holton STW discharges to Holton Mere approximately 1km from the Barrel 'O' monitoring point. A dye tracing exercise undertaken in 2008 failed to record breakout of the effluent plume into the harbour under neap tide conditions. Impacts on the harbour may therefore be intermittent and linked to tidal phasing (spring/neap cycle) and flow conditions in the stream.

Studland STW discharges treated sewage in close proximity to the clam beds in Brands Bay and could have a localised impact on levels of microbiological contamination. No microbiological monitoring is undertaken in this area.

Brownsea Island STW is not owned or operated by Wessex Water. The STW discharges treated sewage effluent to a small watercourse that flows into a 25ha non-tidal saline lagoon at the north east of the island. Water exchange between the lagoon and the harbour is very restricted and consequently the STW discharge is highly unlikely to have a significant effect on levels of contamination of shellfisheries in the harbour.

In addition to discharges from the sewage treatment works listed in Table 4.1, the harbour also receives a number of consented (and unconsented) sewage discharges from domestic properties that are not connected to the sewerage network. These discharges are small (<$5m^3$/day) and the majority discharge to watercourses rather than directly to the harbour.

An unconsented effluent discharge to the harbour from a domestic property at Ower Quay was found during the shoreline survey (Appendix A). The volume of the discharge was estimated to be less than $1m^3$/day and there was no evidence of gross sewage contamination around the outfall. Any impact on levels of contamination of shellfisheries in Ower Bay is anticipated to be localised in extent.

Intermittent sewage discharges (storm and emergency overflows) to shellfisheries represent a significant risk to human health (Garreis, 1994). Storm sewage is untreated sewage in a mixture with surface run off from combined sewerage systems that discharge via combined sewer overflows (CSOs) and/or storm sewer overflows (SSOs). Although some dilution from rainwater is afforded, the bacterial loading of storm discharges is significantly higher than treated sewage effluent (particularly where UV treatment is applied to the latter), with faecal coliform concentrations typically around 10^5-10^6 cfu per 100ml (Kay *et al*., 2000, Lee *et al*., 2003). Emergency discharges of untreated sewage occur in the event of a fault in the sewerage infrastructure (typically a blockage or pump failure).

Intermittent sewage discharges that have the potential to impact on levels of microbiological contamination in the production area are given in Table 4.3 and their locations are shown in the map in Figure 4.1. These discharges are concentrated in the urban areas of Poole, to the north of the harbour and Wareham, to the west of the harbour. Bacteriological tracer studies undertaken by Shucksmith (1978) indicate that intermittent sewage discharges to Holes Bay (including the storm overflow from Poole STW) could potentially impact on the shellfisheries throughout the eastern part of the harbour, although they are unlikely to impact on shellfisheries in the Wareham Channel or the western part of the Upper Wych Channel. Intermittent discharges to the Rivers Frome and Piddle and Lytchett Bay (including the storm discharge from Wareham and Lytchett Minster STWs) have the potential to have a significant impact on levels of contamination of shellfisheries in the Wareham Channel as well as shellfisheries in the wider harbour.

The overflows from Sandbanks Pavilion sewage pumping station (SPS), Seacombe Road SPS, Elgin Road SPS and East Quay SPS are within or close to the cockle fishery in Whitley Lake in the north-east of the harbour and storm or emergency discharges from these assets are likely to have a significant impact on levels of microbiological contamination of shellfish in the vicinity of the discharge point. No microbiological monitoring is currently undertaken in this area.

Table 4.3 *Intermittent sewage discharges to Poole Harbour*

Overflow name	NGR of outfall	Receiving Water
West Mill Crescent (Wareham) CSO	SY 9162 8792	River Piddle
Sandford Lane (Wareham) CSO	SY 9210 8818	River Piddle
Abbots Quay (Wareham) CSO[1]	SY 9230 8717	River Frome
Kings Arms Stoborough CSO	SY 9240 8650	River Frome
South East Wareham SPS	SY 9280 8730	River Frome
Wareham STW storm overflow *	SY 9364 8863	River Piddle
Holton Heath STW storm overflow	SY 9518 9062	Stream to Holton Mere
Corfe Castle STW storm overflow	SY 9611 8314	Corfe River
Corfe Castle Red Lane SPS	SY 9647 8169	Corfe River
Lytchett Minster STW SSO	SY 9682 9228	Lytchett Bay
Moorland Way SPS CSO/EO*	SY 9757 9266	Lytchett Bay
Turlin Main SPS	SY 9836 9220	Lytchett Bay
Rockley Road SPS	SY 9957 9006	Poole Harbour
Creekmoor Lane (Poole)CSO	SZ 0037 9309	Holes Bay
Blandford Road (Poole) SPS	SZ 0047 9047	Holes Bay
Fairview Rd (Poole) CSO	SZ 0050 9639	Holes Bay
Poole Bridge SPS	SZ 0063 9037	Holes Bay
Poole STW storm overflow*	SZ 0073 9360	Holes Bay
East Quay SPS	SZ 0140 9025	Poole Harbour
Seacombe Road (Poole) SPS	SZ 0380 8760	Poole Harbour
Elgin Road (Poole) SPS	SZ 0400 8930	Whitley Lake
Sandbanks Pavilion SPS	SZ 0430 8770	Poole Harbour

*N.B. STW=sewage treatment works, EO=emergency overflow, CSO=combined sewer overflow, SPS=sewage pumping station, * indicates spill reporting requirement*

Information on the occurrence and duration of storm overflows is available for Poole STW, Wareham STW, Lytchett Minster STW and Moorlands Way sewage pumping station (SPS). A summary of spill data for these assets is given in Table 4.4. It is notable that Moorland Way SPS, which discharges to Lytchett Bay, has spilt over 20 times in each of the last three years against a design standard of 10 significant (>50m^3) spills per year on average over ten years in aggregation with other intermittent discharges.

The spill frequencies of other intermittent discharges to Poole Harbour are in general thought to be satisfactory, although the EA does have some concerns regarding the operation of Elgin Road SPS (Nick Smart, Environment Agency, personal communication). This site is scheduled to have event/duration monitoring by 2015.

Table 4.4 *Numbers of spills per year recorded at monitored storm overflows to Poole Harbour (Data supplied by the Environment Agency)*

Site	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
Poole STW	4	2	4	26	1[c]	4[c]
Lytchett Minster STW	14	13	No data[a]	4	17[d]	5
Wareham STW	1	4	0	8	2	6
Moorlands Way SPS	12	12	7	>24[b]	20	23

a No data for entire period due to instrument failure
b No data from 06/03/07 to 31/03/07
c No data from 01/04/07 to 15/07/08 due to damage to instrument cable. Spill from operator's records.
d 1 spill of 9.3hrs on 26/03/08 due to STW inlet penstock control failure (NIRS 573514)

In addition to the sewage discharges listed in Table 4.1 and 4.3, there are several continuous and intermittent discharges in the wider catchment that will contribute to *E. coli* concentrations in the rivers and streams draining to Poole Harbour (see Section 4.2 below). The most significant of these are the effluent discharges from Dorchester STW, which discharges to the River Frome over 20km upstream of the tidal limit, and Wool STW, which discharges to the River Frome over 10km upstream of the tidal limit.

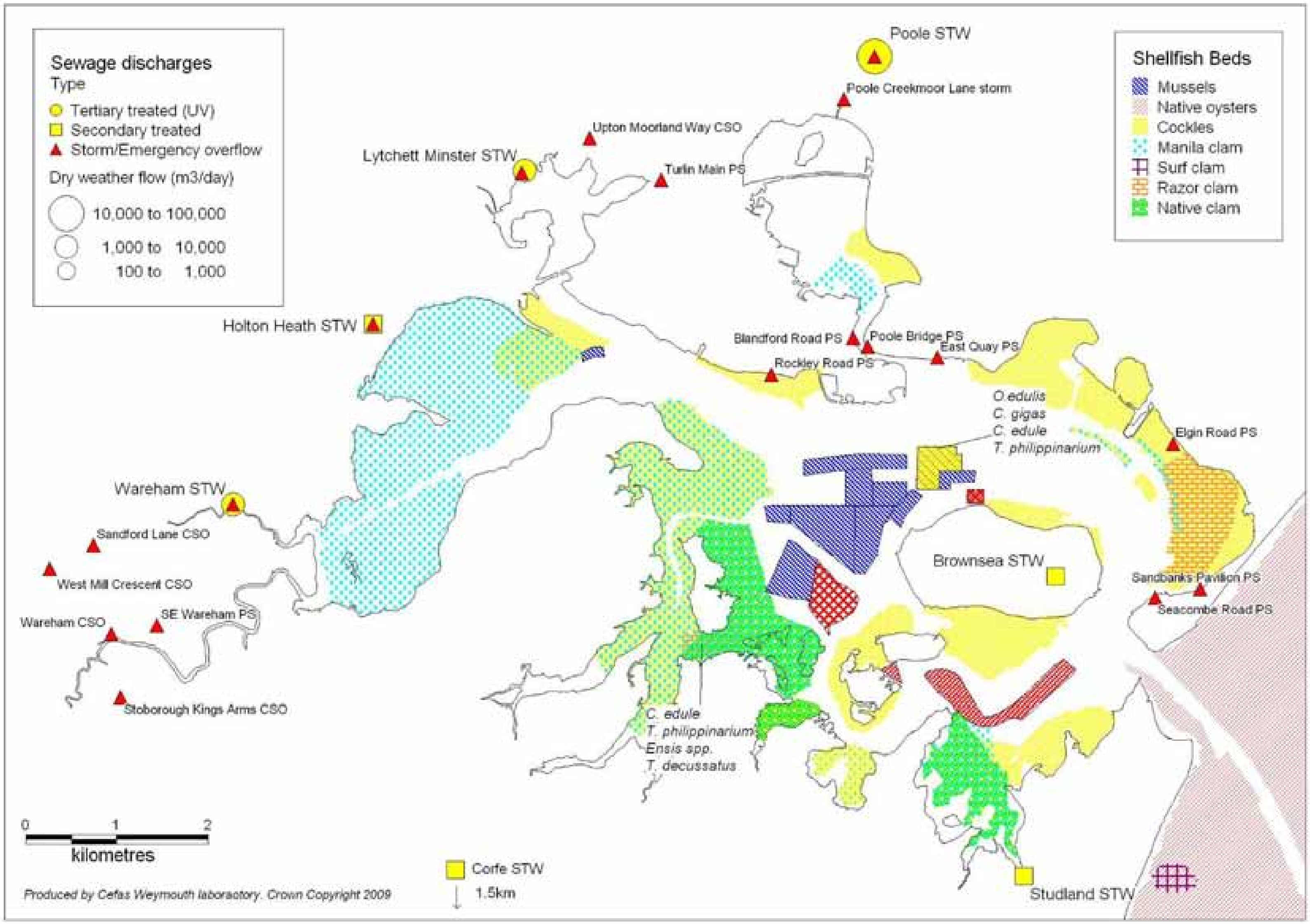

Figure 4.1: *Sewage discharges to Poole Harbour*

4.2 Rivers and streams

Rivers and streams that receive point and diffuse sources of pollution can be significant sources of microbiological contamination of coastal waters, particularly during high flow conditions (Kay *et al*., 2000). The main freshwater inputs to Poole Harbour are the River Frome and River Piddle, both of which discharge to the west of the harbour near Wareham. Mean flows for foot of catchment gauging stations in these rivers are 6.4 and 2.4 m^3s^{-1} respectively (National River Flow Archive, CEH, 2009). The estuary also receives smaller freshwater inputs from the Corfe River, which discharges to Wych Lake, and the Sherford River, which discharges to Lytchett Bay. These rivers are not gauged but their mean flows have been estimated to be approximately $0.5m^3s^{-1}$ (Sherwin and Menhinick, 2001; Langston *et al*., 2003).

Seasonal variation in flow in the Frome and Piddle is shown in Figure 4.2. Mean flows are highest in the winter (December to February) and loads of faecal indicator organisms to the harbour are anticipated to be highest during this period.

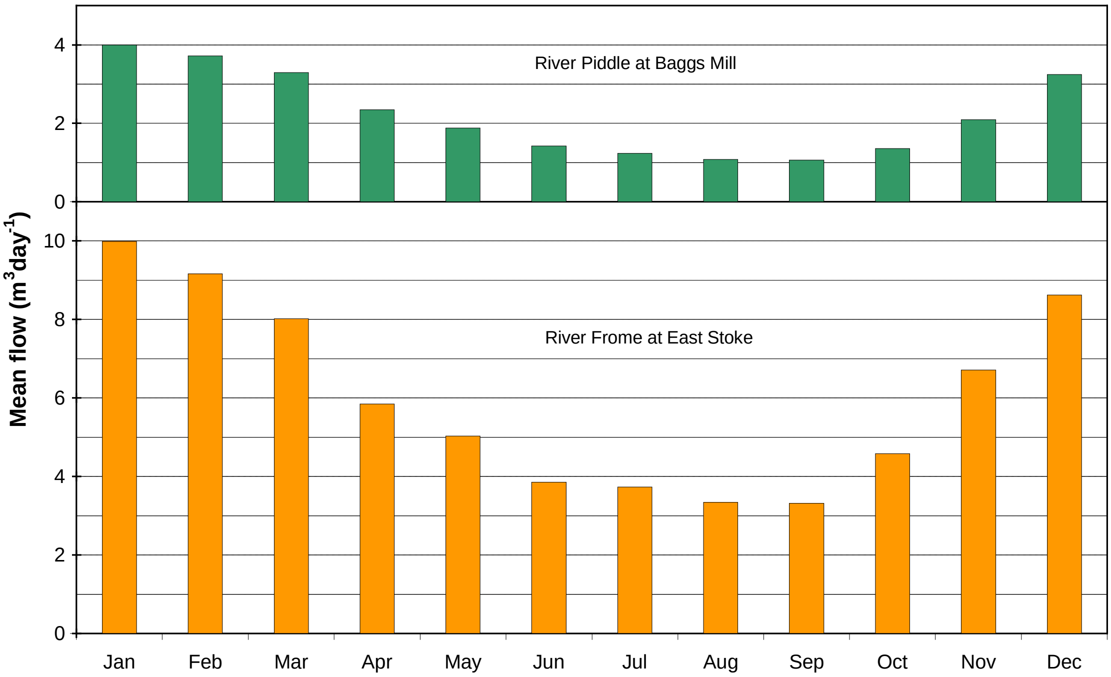

***Figure 4.2** Mean monthly flow in Frome and Piddle, 2004 to 2009 (Data source Environment Agency).*

A summary of available bacteriological data for rivers and streams sampled by the Environment Agency is presented in Table 4.5. The geometric mean faecal coliform concentrations for the Frome, Piddle, Corfe and Sherford are higher than those for the disinfected effluents from the STWs (see Table 4.2). This suggests that the rivers are likely to be a more significant source of microbiological contamination of shellfisheries than the major STWs around Poole Harbour, even during base flow conditions.

The limited data that is available for the stream downstream of Holton Heath STW indicates that the stream is contaminated by effluent from the STW. This stream could be a localised source of contamination of shellfisheries in Holton Mere.

***Table 4.5** Summary of faecal coliform data (cfu/100ml) for freshwater inputs to Poole Harbour (Data source Environment Agency).*

Site	No. of samples	Geometric mean	Minimum result	Maximum result
Corfe River d/s Corfe STW[a]	24	990	102	7,000
River Frome at Wareham[b]	18	740	240	4,000
Holton Heath stream d/s STW[c]	3	10,000	3,200	37,000
River Piddle at West Mills[d]	16	420	36	2,600
Sherford River at King Bridge[e]	154	1,200	115	73,000

a Data for period 2002-2004. Sampled at NGR SY 967 842
b Data for period 2004-2006. Sampled at NGR SY 923 872
c Data for 2004 only. Sampled at NGR SY 954 906
d Data for period 2003-2006. Sampled at NGR SY 915 876
e Data for period 2002-2008 (May to September only). Sampled at NGR SY 954 924

ADAS (2003) developed a catchment level model (Catchment Source Apportionment Tool, CSAT) to calculate the faecal coliform load exported from the Frome and Piddle catchments to Poole Harbour. The model incorporated the loads from both point sources (STWs and CSOs) and diffuse organic wastes spread to agricultural land (both naturally from livestock and artificially applied as manure or slurry). The model calculated that point sources are responsible for more than 95% of the annual faecal coliform load exported from the catchment, with CSOs being the most significant source during storm events. Predicted faecal coliform concentrations at the tidal limit showed a seasonal pattern with concentrations peaking in the winter. This may partly account for the similar seasonal pattern in *E. coli* levels in shellfish seen at several sites in the harbour (See section 5).

The relatively low contribution of diffuse agricultural inputs to the overall faecal coliform budget of the Frome and Piddle can be attributed to the chalk nature of their catchments and relative unimportance of rainfall generated run off. In contrast, the Corfe and Sherford Rivers drain clay catchments and respond much more rapidly to rainfall. Diffuse agricultural inputs may therefore be a more significant source of contamination in the Corfe and Sherford Rivers.

Levels of microbiological contamination from the rivers and streams discharging to Poole Harbour are anticipated to be highest in areas of low salinity close to their tidal limits where dilution of the effluent by seawater will be minimal. The impact of contamination from the Frome and Piddle is therefore expected to be highest in the upper reaches of the Wareham Channel. The classified harvesting area in the Wareham Channel currently extends as far west as Gigger's Island. This area is classified using the monitoring point at Barrel 'O' which may not be representative of worst case levels of contamination. Similarly, the classified harvesting area in Wych Lake in the south of the harbour currently extends to the tidal limit of the Corfe River. This area is classified by the Round Island monitoring point (approximately 2.5km from the tidal limit) which may not be representative of worst case levels of contamination. The Sherford River drains to Lytchett Bay which is currently prohibited for bivalve production.

4.3 Wildlife

Previous studies have demonstrated that birds can be a significant source of microbiological contamination of coastal waters (Obiri-Danso and Jones, 2000; Jones, 2005; Wither *et al*., 2005). Poole Harbour is designated as a Special Protection Area (SPA) under the EC Birds Directive and regularly supports more than 20,000 birds during the winter months (Austin *et al*., 2008). Most of the bays and inlets around Poole Harbour offer suitable feeding habitat for various species of waders and wildfowl at low water (Banks *et al*., 2006), and therefore birds may contribute to background levels of contamination of shellfisheries throughout the harbour and may be a significant source of contamination in intertidal areas.

Mean peak counts of key waterbird species in Poole Harbour over the five year period 2002/03 to 2006/07 are given in Table 4.6. Numbers of most species peak during the winter months (November to February) and the risk of microbiological contamination from this source is expected to be greatest during this period.

Table 4.6 *Peak counts of important waterbirds in Poole Harbour, 2002/03 to 2006/07 (Data source Austin et al., 2008)*

Species	Mean peak count	Peak month
Avocet	1,334	Feb
Black headed gull	17,707	Nov
Black tailed godwit	2,116	Feb
Common greenshank	19	Oct
Cormorant	443	Sept
Curlew	1,660	Jan
Dark bellied brent goose	1,153	Feb
Dunlin	7,026	Jan
Little egret	179	Nov
Pintail	282	Jan
Red breasted merganser	347	Jan
Shelduck	2,001	Feb
Teal	1,950	Nov
Water rail	24	Nov

The harbour also supports several large breeding colonies of black headed gulls (*Larus ridibundus*). The largest gull colonies are on the saltmarsh islands in Holton Mere in the Wareham Channel. A total of 8951 occupied nests were counted here in May 2008 (Seabird Monitoring Programme Online Database, JNCC 2009). These islands are flooded on high water spring tides and faecal material from these colonies may therefore contribute significantly to background levels of contamination of the clam beds in this area during the breeding season. The Barrel 'O' monitoring point is within 500m of the islands (Figure 4.3).

A large population of feral sika deer (*Cervus nippon*), estimated to be up to 3000 individuals, has become established in Purbeck. A group of 500-700 animals is present at Arne (Diaz *et al*., 2005), and deer were observed on the shoreline at Arne during the shoreline survey (Appendix A). Droppings deposited on the intertidal areas may contribute to background levels of microbiological contamination, particularly in the Wych Lake area. Grey seals (*Halichoerus grypus*) are occasionally observed in the harbour but are unlikely to be a significant source of contamination.

Figure 4.3 *Aerial photograph showing location of black headed gull colonies in Holton Mere in relation to Barrel 'O' monitoring point. Counts are of numbers of occupied nests in May 2008. Photograph © Dorset County Council 2000.*

4.4 Waste discharges from boats

Whilst sewage discharges from boats are likely to be small in comparison with direct discharges from sewage treatment works, there is a potential contamination risk associated with the intermittent discharge of small quantities of raw sewage from sea toilets and holding tanks of recreational craft (The Green Blue, 2008; Garreis, 1994).

Poole Harbour is exceptionally popular for yachting and there are approximately 2500 swinging moorings within the Harbour as well as around 2300 sheltered marina and pontoon berths (Poole Harbour Steering Group, 2006). The Environment Agency also has over 100 moorings along the River Frome, downstream of South Bridge at Wareham. The swinging moorings are grouped in several locations around the Harbour with the main concentrations being around the north shore and adjacent to the channels north and east of Brownsea Island. In addition, there are six house boats permanently moored at Bramble Bush Bay near Studland. An occupied houseboat was also observed near Round Island during the shoreline survey (Appendix A).

It is noteworthy that a local byelaw prohibits the emptying of marine toilets and holding tanks into harbour waters, and sewage pump out facilities are provided at both Poole Quay Boat Haven and Salterns Marina (The Green Blue, 2006). These measures should go some way to reducing the risk of contamination of shellfisheries due to waste discharges from boats.

4.5 Farms

There are areas of grazing land bordering the south and west of Poole Harbour and several beef and dairy farms in close proximity to the shore. Discharges and run off of farm waste (slurry or manure) from these farms have the potential to contribute to levels of microbiological contamination in shellfisheries in these areas. However, the Environment Agency is not aware of any issues at these farms that suggest they are a significant source of contamination (Julian Wardlaw, Environment Agency, personal communication).

5 REVIEW OF MICROBIOLOGICAL DATA

5.1 Seawater

Levels of faecal coliforms in the water column at designated Shellfish Waters Directive monitoring points in the harbour are monitored on a minimum of four occasions each year by the Environment Agency (EA). In addition, the EA has undertaken monthly monitoring at three additional sites in order to assess the impact of UV disinfection at Poole, Wareham and Lytchett Minster STWs on water quality in the harbour. The locations of these sites are shown in Figure 5.1. A summary of faecal coliform data for the period 2003-2009 (post completion of the UV disinfection schemes) is given in Table 5.1. Whilst levels of faecal contamination in the water column are generally low, sporadic results above 1000 faecal coliform per 100ml have been recorded. Levels of microbiological contamination are highest in the Wareham Channel and in the mouths of Holes Bay and Lytchett Bay. This reflects inputs from the rivers and discharges to these areas.

Table 5.1 *Summary of water column faecal coliform data (No. per 100ml, presumptive count) for sites in Poole Harbour, 2003-2009 (Data source Environment Agency)*

Site	Number of samples	Geometric mean	Minimum result	Maximum result
Rockley Viaduct	53	41	<10	1,040
Wareham Channel	66	40	<2	4,000
Poole Bridge	67	39	<2	31,000
Hutchins Buoy	58	9	<2	790
South Deep	30	3	<2	158
Salterns Marina	31	3	<2	500

There are EC designated bathing waters within Poole Harbour at Rockley Sands and Lake (Figure 5.1). There is also a non-designated bathing water at Hamworthy Park. Levels of faecal indicator organisms (total coliforms, faecal coliforms and faecal streptococci) in seawater at these sites are monitored weekly from May to September by the EA. The compliance history at the designated sites against the guideline and imperative standards of the Bathing Waters Directive (76/160/EEC)[2] is given in Table 5.2.

Table 5.2 *Bathing water quality in Poole Harbour (Data source Environment Agency)*

Bathing Water	2000	2001	2002	2003	2004	2005	2006	2007	2008
Rockley Sands	I	I	I	G	G	I	G	G	G
Lake	G	G	G	G	G	G	G	G	G

G=meets guideline standard, I=meets imperative samples

[2] 95% of samples must conform to a faecal coliform concentration of less than 2000cfu per 100ml and a total coliform concentration of less than 10,000cfu per 100ml in order for a site to pass the Imperative (I) standards of the Directive. 80% of samples must conform to a faecal coliform concentration of less than 100cfu per 100ml in order to meet Guideline (G) standards. In England and Wales, guideline compliance is also assessed against a national faecal streptococci standard of 100 per 100ml (as an 80 percentile).

Lake Bathing Water has passed the guideline standard of the directive in every year since 2000. An improvement in compliance with the guideline standard is evident at Rockley Sands Bathing Water, which has passed the guideline standard in every year since 2003 except 2005. This can be attributed to the commissioning of UV disinfection at the major STWs in March 2003, and in particular at Lytchett Minster STW which discharges to Lytchett Bay.

A summary of faecal coliform data for the period 2003-2008 (post completion of the UV disinfection schemes) for bathing waters within Poole Harbour is given in Table 5.3. The results are similar to those obtained from water column monitoring of shellfish waters in the harbour (see above) and indicate that whilst water quality is generally very good, relatively high levels of contamination (>1,000 faecal coliforms per 100ml) are recorded occasionally.

Table 5.3 *Summary of faecal coliform data (cfu/100ml) for bathing water sites in Poole Harbour, 2003-2008 (Data source Environment Agency)*

Site	Number of samples	Geometric mean	Minimum result	Maximum result
Rockley Sands	120	30	2	1,240
Lake	120	12	<2	1,632
Hamworthy Park[a]	80	7	<2	450

Data collected during bathing season (May to September) only.
a Monitoring at Hamworthy Park started in 2005

5.2 Shellfish flesh

Shellfish samples for hygiene classification purposes are collected by Poole Harbour Commissioners (PHC) on behalf of Poole Borough Council (PBC). Samples are analysed for *E. coli* by Wessex Environmental Microbiology Service (WEMS). Sampling is predominantly undertaken at high water on spring tides due to difficulties in accessing shallow areas of the harbour at other states of tide. The locations of current hygiene monitoring points in the harbour are shown in Figure 5.2. The practical reasons[3], bagged samples of mussels are used to classify the majority of the farmed and wild shellfish beds in the harbour, including the clam beds in the Wareham Channel. Occasional samples of dredged clams are collected at Barrel ‘O’ and Rockley for comparative purposes.

A summary of the *E. coli* data for the period 2004 to 2009 (post completion of the UV disinfection schemes) is given in Table 5.4. Sporadic results above 4,600 MPN per 100g have been recorded at all sites within the harbour. The highest levels of contamination have been recorded at Barrel ‘O’ and Rockley monitoring points in the Wareham Channel. Both sites have returned *E. coli* levels above 46,000 MPN per 100g (i.e. ‘Prohibited’ level results). Levels of contamination at two sites outside of the harbour (Hook Sands and Bournemouth Pier) are low, with all *E. coli* results at both sites less than 4,600 MPN per 100g.

[3] It has proved impractical to dredge clams outside of the short harvesting season, and clams do not survive well in sampling bags.

Figure 5.1 *Water quality monitoring points in Poole Harbour*

Geometric mean levels of *E. coli* in Manila clams at Barrel 'O' and Rockley are higher than those recorded in mussels at the same sites. This difference is statistically significant for Barrel 'O' (2 sample t-test, P<0.02). In experiments undertaken in Poole Harbour, Lart and Hudson (1993) found that Manila clams had significantly higher *E. coli* counts than mussels during the early spring whilst *E. coli* counts in native clams were not significantly different from mussels under these conditions. Whilst the practical difficulties of sampling clams year round are recognised, these observations suggest monitoring of mussels in order to classify areas for harvesting of Manila clams may not be appropriate.

In order to examine seasonal variation in levels of microbiological contamination in the production area, samples were classified into those collected in spring (March to May), summer (June to August), autumn (September to November) and winter (December to February). Box plots illustrating variation in the distribution of *E. coli* results by season are shown in Figure 5.3. Seasonal variation in *E. coli* levels was evident at several sites, with the highest levels of contamination in the winter and lowest levels of contamination in the summer. There were statistically significant seasonal differences in geometric mean *E. coli* levels for mussels from Hamworthy and Northwytch and for Manila clams from West Brownsea 2 (ANOVA, P<0.05). Similar seasonal variation in levels of contamination of shellfish in the harbour has previously been attributed to variations in *E. coli* concentrations at the tidal limits of the Rivers Frome and Piddle (ADAS, 2003). However, seasonal variation in faecal inputs from birds may also be important given that numbers of waders and wildfowl in the harbour peak during the winter months. It is noteworthy that no seasonal variation in *E. coli* levels is evident at Barrel 'O', the site showing the highest levels of contamination.

The relationships between *E. coli* concentrations in shellfish and river flow in the Frome and Piddle on the day of sampling and the day before sampling were investigated using Pearson's product-moment correlation coefficient (r). The locations of the flow gauging stations on the Frome and Piddle are shown in figure 5.4. Both the river flow (sum of mean daily flows in Piddle at Baggs Mill and Frome at East Stoke) and *E. coli* concentration data were log-transformed to improve normality of the data. The results of the correlation analysis are presented in Table 5.5. *E. coli* levels were significantly positively correlated with river flow at six of the ten sites examined, the strength of the correlation being generally slightly greater with flow on the day before sampling than with flow on the day of sampling. The strongest correlation was for mussels at Northwytch where river flow on the day before sampling explained 27% of the variation in *E. coli* levels.

Figure 5.2 *Shellfish hygiene monitoring points in Poole Harbour sampled since 2004*

Table 5.4 *Summary of E. coli data (MPN per 100g) for shellfish hygiene monitoring points in Poole Harbour, Jan 2004 to Mar 2009*

Bed ID	Bed Name	Species	Number of Samples	No. Samples <20	Geometric Mean	Minimum	Maximum	% Compliance with 4,600	No. samples >46,000
B54BS	Barrel ‘O’	*Mytilus* spp.	56	0	1,320	50	54,000	85.7	1
B54BR	Rockley	*Mytilus* spp.	56	1	560	<20	54,000	92.9	1
B54BM	Round Island	*Mytilus* spp.	60	5	270	<20	11,000	95.0	0
B54BT	Rockley East	*Mytilus* spp.	58	0	390	40	16,000	96.6	0
B54AS	South Deep	*Mytilus* spp.	52	17	70	<20	5,400	98.1	0
B054P	Hamworthy	*Mytilus* spp.	62	1	280	20	5,400	98.4	0
B054M	Northwytch	*Mytilus* spp.	63	9	170	<20	5,400	98.4	0
B54BL	West Brownsea 1	*C. gigas*	39	7	120	10	5,400	97.4	0
B54BA	West Brownsea 1	*C. edule*	58	2	330	20	9,200	93.1	0
B54AH	South Deep Relaying	*Mytilus* spp.	2	1	15	<20	20	100.0	0
B054C	South Deep	*O. edulis*	1	0	110	110	110	100.0	0
B54AK	Rockley	*T. phillipinarum*	2	0	1,600	750	3,500	100.0	0
B54CE	Holes Bay	*T. phillipinarum*	10	0	1,900	310	7,000	80.0	0
B54AB	West Brownsea 2	*T. phillipinarum*	56	1	390	20	16,000	94.6	0
B54AL	Barrel "O"	*T. phillipinarum*	12	0	3,600	750	54,000	66.7	1
B54CH[a]	West Brownsea 2	*Mytilus* spp.	5	0	290	70	1,800	100.0	0
B54BB	PE529-Hook Sands[b]	*Mytilus* spp.	44	18	60	<20	3,500	100.0	0
B54BF	PE529-Bournemouth Pier[b]	*Mytilus* spp.	47	15	60	<20	3,500	100.0	0

[a] *new sample point introduced from 02/10/08 to replace B54BA and B54AB*
[b] *these sampling points are outside of Poole Harbour and are included here for comparative purposes*

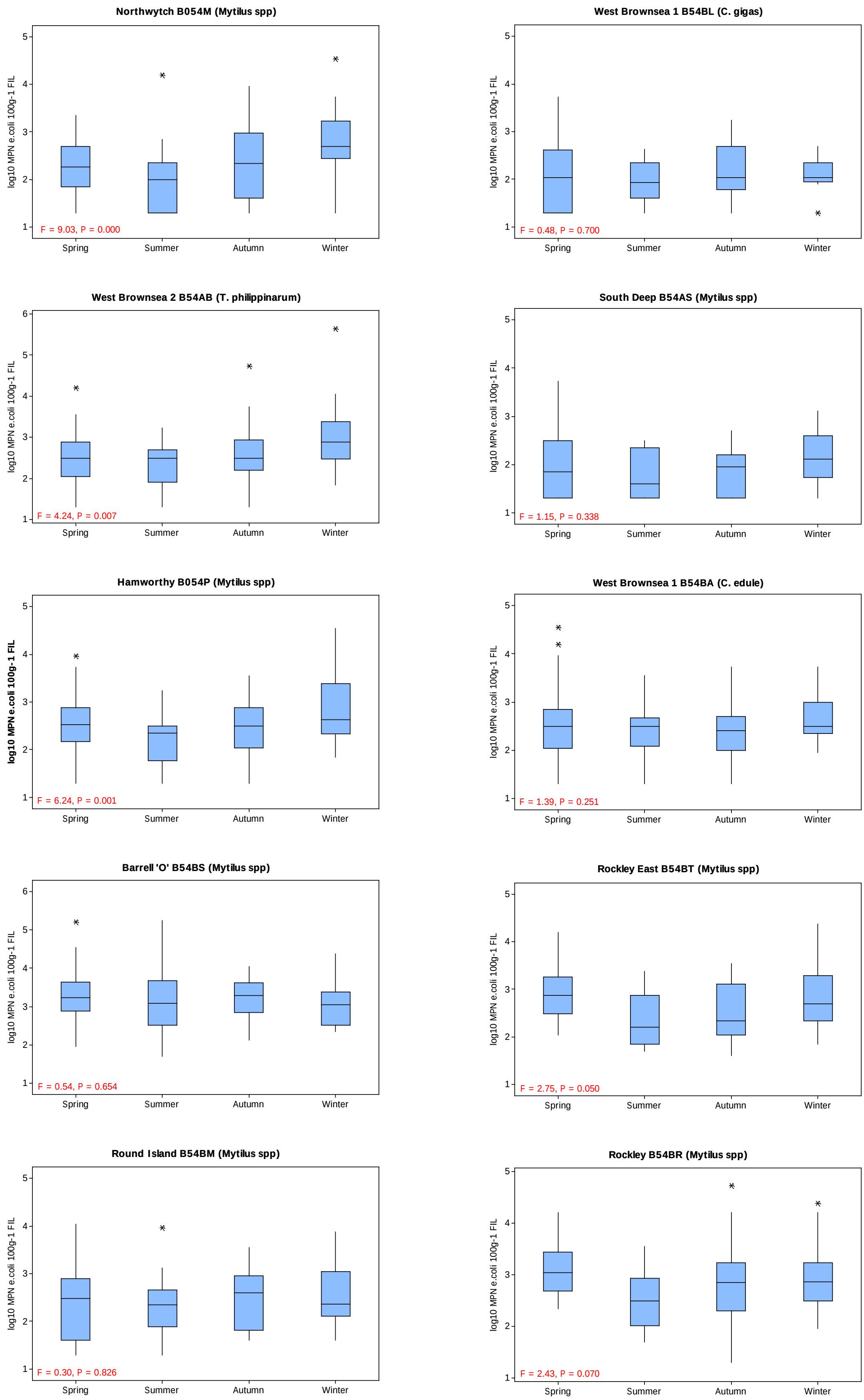

***Figure 5.3** Box plots showing seasonal variation in E. coli concentrations in shellfish*

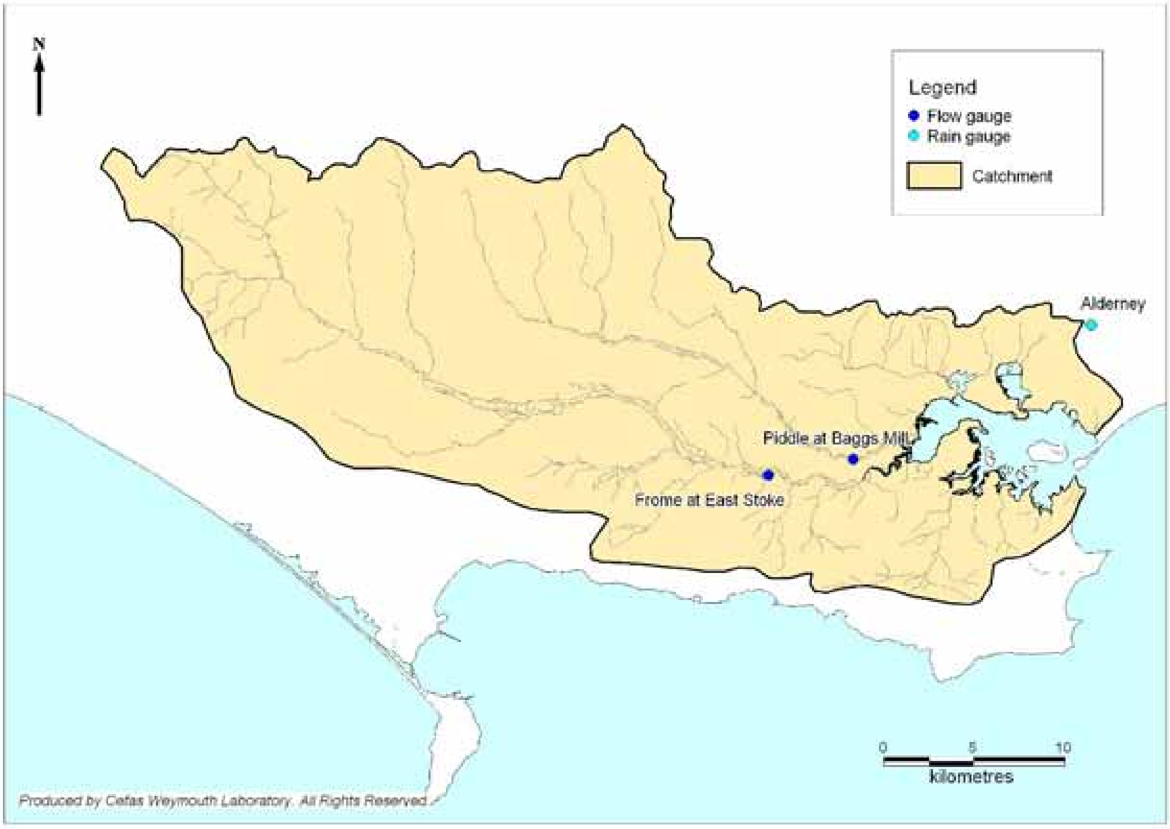

Figure 5.4 *Locations of river flow and rain gauging stations used to examine the effects of rainfall and river flow on E. coli concentrations in shellfish in Poole Harbour*

Table 5.5 *Results of Pearson's correlation between E. coli concentrations in shellfish and combined river flow in Frome and Piddle (all data log-transformed)*

Site	Mean flow on day of sampling			Mean flow on day prior to sampling		
	n	*r*	*p*	*n*	*r*	*p*
B54BS Barrel O (M)	54	0.012	n/s	54	0.030	n/s
B54AS South Deep (M)	51	0.259	n/s	51	0.257	n/s
B054M Northwytch (M)	61	0.481	<0.001	61	0.516	<0.001
B54BT Rockley E (M)	57	0.274	<0.050	57	0.287	<0.050
B54BM Round Island (M)	58	0.238	n/s	58	0.280	<0.050
B54BR Rockley (M)	54	0.161	n/s	54	0.173	n/s
B054P Hamworthy (M)	60	0.253	<0.050	60	0.251	<0.050
B54AB W Brownsea 2 (C. e)	56	0.270	<0.050	56	0.279	<0.050
B54BA W Brownsea 1 (T. ph)	58	0.266	<0.050	58	0.270	<0.050
B54BL W Brownsea 1 (C. g)	37	0.244	n/s	37	0.281	n/s

n=number of samples, r=Pearson correlation coefficient, p=probability, n/s=not significant, M=mussels, C. e=cockles, T. ph=Manila clam, C. g=Pacific oysters

The relationships between *E. coli* concentrations in shellfish and total rainfall in the 24 and 48 hours prior to sampling were also investigated using correlation techniques. Cumulative rainfall was calculated for the Environment Agency rain gauge at Alderney near Poole (see Figure 5.4), and the *E. coli* concentration (but not the rainfall) data were log-transformed to improve normality. The results of the correlation analysis are shown in Table 5.6. Statistically significant positive correlations between *E. coli* concentrations in shellfish and antecedent rainfall were only detected at South Deep and West Brownsea 2. The strongest correlation was between rainfall in the 48 hours prior to sampling and *E. coli* concentrations in mussels at South Deep where rainfall explained 22% of the variation in *E. coli* concentration.

Table 5.6 *Results of Pearson's correlation between E. coli concentrations in shellfish and rainfall at Alderney (E. coli data log-transformed)*

Site	Rainfall in 24 hours prior to sampling			Rainfall in 48 hours prior to sampling		
	n	*r*	*p*	*n*	*r*	*p*
B54BS Barrel O (M)	62	-0.196	n/s	62	-0.070	n/s
B54AS South Deep (M)	55	0.404	<0.01	55	0.465	<0.001
B054M Northwytch (M)	70	-0.092	n/s	70	-0.081	n/s
B54BT Rockley E (M)	61	-0.092	n/s	61	0.060	n/s
B54BM Round Island (M)	67	-0.161	n/s	67	0.047	n/s
B54BR Rockley (M)	59	-0.108	n/s	59	-0.014	n/s
B054P Hamworthy (M)	69	0.019	n/s	69	0.074	n/s
B54AB W Brownsea 2 (C. e)	63	0.153	n/s	63	0.263	<0.05
B54BA W Brownsea 1 (T. ph)	65	0.143	n/s	65	0.216	n/s
B54BL W Brownsea 1 (C. g)	37	-0.122	n/s	37	0.041	n/s

n=number of samples, r=Pearson correlation coefficient, p=probability, n/s=not significant, M=mussels, C. e=cockles, T. ph=Manila clam, C. g=Pacific oysters

The above results suggest that catchment sources of contamination are more significant than rainfall related sources in close proximity to the harbour such as storm overflows or run-off from urban areas. It is important to note that correlation does not necessarily imply causation and that river flow is likely to be correlated with both rainfall and season.

6 OVERALL ASSESSMENT

A summary of sources of microbiological contamination to Poole Harbour is presented in Figure 6.1.

Given that the effluents from the major point source sewage discharges to the harbour (Poole, Wareham and Lytchett Minster STWs) now receive year round UV disinfection, the highest levels of microbiological contamination in the harbour are expected to be found close to the tidal limits of the main freshwater inputs to the harbour (i.e. the River Frome, River Piddle, Corfe River and Sherford River). The monitoring point at Round Island is considered to be representative of levels of contamination of shellfisheries in the Wych Channel area that may be impacted by the Corfe River. Similarly, the monitoring point at Rockley is located close to the mouth of Lytchett Bay into which the Sherford River flows. However, the monitoring point at Barrel 'O' is located approximately 2km from the western boundary of the classified harvesting area in the upper reaches of the Wareham Channel where the Rivers Frome and Piddle meet, and this monitoring point might not be representative of levels of contamination in this area.

Levels of microbiological contamination are also anticipated to be locally elevated close to inputs from small STWs that do not receive UV disinfection. Holton Heath STW discharges to a stream that flows into Holton Mere close to the Barrel 'O' monitoring point, and may be the source of the relatively high levels of contamination seen at this site. Studland STW discharges into the classified harvesting area in Brands Bay and a representative monitoring point should be located in this area.

Several storm overflows are located on the north shore of the harbour and in the Wareham area and storm sewage discharges will result in elevated levels of microbiological contamination in the harbour following rainfall. Storm discharges from several overflows from the north shore could potentially impact on shellfisheries throughout the eastern harbour, although with the exception of the storm overflow from Poole STW, no information is available on the spill frequency of these discharges. Whilst existing monitoring points are generally well placed in relation to these sources, there is currently no monitoring point in the wild cockle beds in the Whitley Lake area. Storm discharges to the River Frome and Piddle from overflows in the Wareham area could impact on shellfisheries in the Wareham Channel. Further efforts to obtain information on storm overflows should be sought and assessed at the next review.

Birds and other wildlife (notably sika deer) are likely to be a significant source of microbiological contamination throughout the harbour, particularly in intertidal areas and close to the saltmarsh islands in the Wareham Channel. However, given the diffuse nature of these inputs it is not considered necessary to locate additional sampling points in relation to these sources. Seasonal variation in bird numbers may partly account for seasonal variation seen in *E. coli* levels in shellfish at several sites.

The majority of shellfish beds in the harbour are currently classified by monitoring bagged samples of mussels. Limited additional monitoring of dredged Manila clams (*Tapes philippinarum*) has demonstrated that levels of *E. coli* are significantly higher in clams than in mussels. Whilst the practical difficulties involved in sampling clams year-round are recognised, sampling clams directly would be most protective of public health.

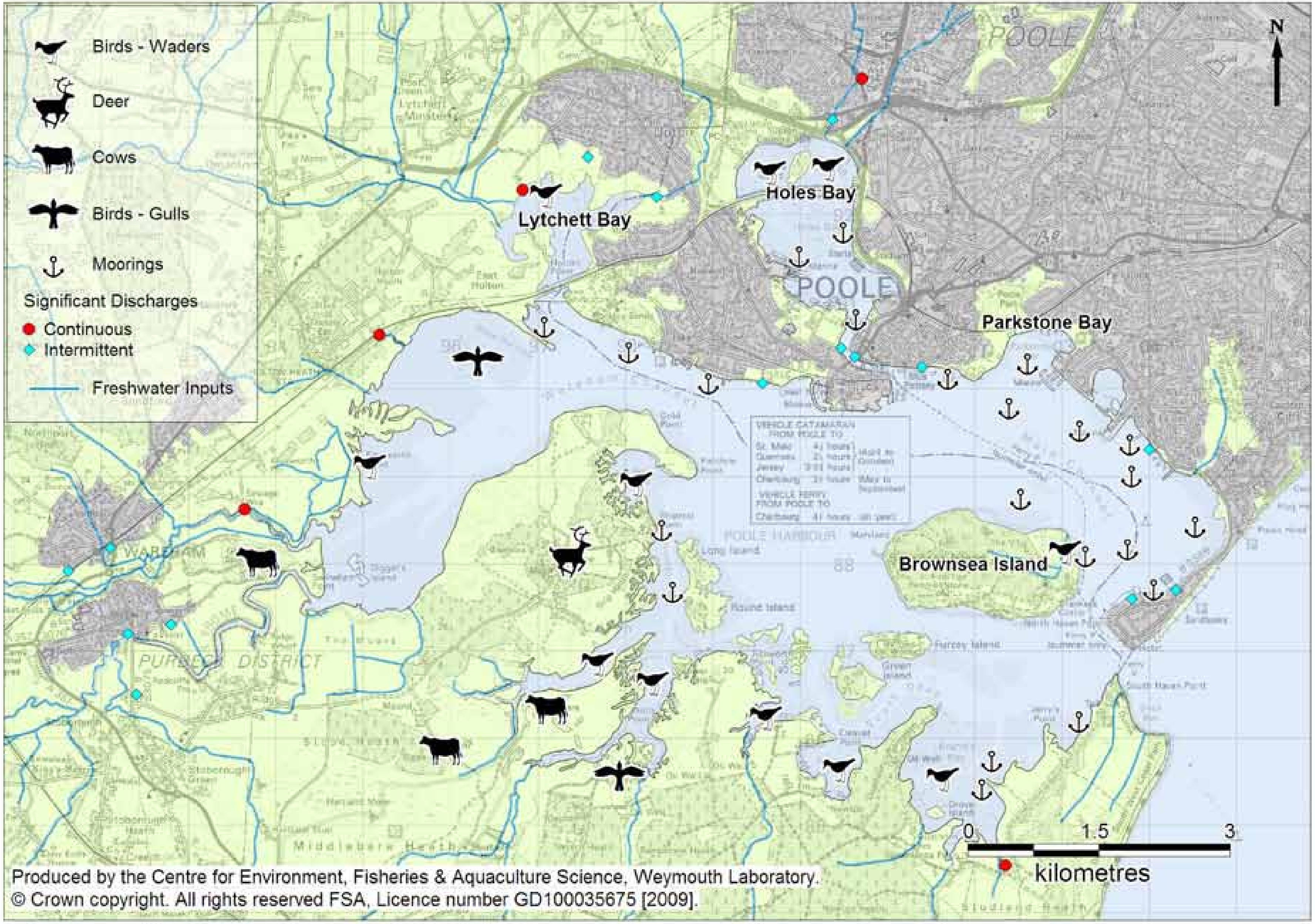
Birds - Waders
Deer
Cows
Birds - Gulls
Moorings
Significant Discharges
Continuous
Intermittent
Freshwater Inputs
Lytchett Bay
Holes Bay
POOLE
Parkstone Bay
Brownsea Island
WAREHAM
PURBECK DISTRICT
N
0
1.5
3
kilometres
Produced by the Centre for Environment, Fisheries & Aquaculture Science, Weymouth Laboratory.
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Figure 6.1 *Summary of contamination sources to Poole Harbour production area*

7 RECOMMENDATIONS FOR MONITORING AND CLASSIFICATION

Recommended classification zones and representative monitoring points are shown in the sampling plan in Appendix B. Note that the classification zone boundaries are different from those previously used. There are a total of nine sampling points recommended (there were also nine prior to the sanitary survey). Specific recommendations for monitoring are:

1. In order to determine if the Barrel 'O' monitoring point is representative of levels of contamination in the upper reaches of the Wareham Channel, a limited number of bagged samples of mussels were collected from the main channel near the confluence of the Rivers Frome and Piddle at the same time as samples are collected from Barrel 'O' (note that this area is accessible by boat at high water). This monitoring was undertaken during the winter months when levels of contamination are anticipated to be highest. Levels of *E. coli* contamination were found to be lower in the upper reaches of the Wareham Channel than at Barrel 'O'. Therefore Barrel 'O' is recommended to be retained to classify the wild clam and cockle beds in the Wareham Channel. This site is close to both the gull colony at Holton Mere and the effluent discharge from Holton Heath STW. The LEA is not able to sample clams due to resource constraints and so bagged mussels are used as a representative species.

2. Rockley (B54BR) should be used to classify the farmed mussel and wild clam and cockle beds in the Rockley Channel. This site is well placed to reflect contamination sources from Lytchett Bay, and monitoring at Rockley has revealed higher levels of *E. coli* contamination (mean and maximum) than at the nearby Rockley East monitoring point. Monitoring at Rockley East could cease.

3. Hamworthy (B054P) should be used to classify the farmed and wild mussel, clam and cockle beds in Poole Harbour North. Hamworthy is well placed to reflect contamination from the main freshwater inputs to the harbour.

4. West Brownsea (B54BL) should be used to classify the farmed native and Pacific oysters in Poole Harbour North.

5. Monitoring at Northwytch and West Brownsea 2 could cease. If separate classification of the farmed native or Pacific oysters in this area is required, a new monitoring point should be introduced at the relevant bed(s).

6. A new monitoring point at North Haven Yacht club (B54CN) should be introduced at Whitley Lake in order to classify the wild cockle beds in this zone. Monitoring at this site is recommended because of the potential for contamination from intermittent sewage discharges in this area. The monitored species should be cockles. The LEA is not able to sample cockles due to resource constraints and so bagged mussels are used as a representative species.

7. Round Island (B54BM) should be used to classify all species in the Poole Harbour South Zone. This site is well placed to reflect contamination from the Corfe River and Corfe STW, and monitoring at Round Island has revealed higher

levels of *E. coli* contamination (mean and maximum) than at the adjacent Northwytch monitoring point.

8. A monitoring point should be established at West Brownsea 3 (west cardinal marker). *C. gigas* (B54CK) and mussels (B54CL) will be sampled at this location. This sampling will represent *Tapes* spp. and cockles (represented by mussels) and both oyster species (represented by *C. gigas* monitoring).

9. The monitoring point at South Deep (B54AS) should be used to classify the native oyster relay site in this area. It is recommended that monitoring at this site is maintained so that these beds can be classified independently of those in adjacent zones. The current monitoring point is well placed to reflect contamination derived from sources outside the harbour, although it would be preferable to monitor native oysters directly at this site rather than use bagged mussels since it is possible that this would result in a more favourable classification.

10. A new monitoring point should be introduced at Brands Bay in order to classify the wild clam and cockle beds in this area. Monitoring at this site is recommended because of the potential for contamination from the effluent discharge from Studland STW. The monitored species should ideally be clams (at least initially), although the practical difficulties in sampling clams year-round are recognised. Since the LEA is not able to sample clams due to resource constraints, bagged mussels will be used as a representative species.

11. Due to practical difficulties in sampling clams and cockles bagged mussels will continue to be used as a representative species. Although this is not ideal, it has been shown in Cefas studies that mussels, cockles and Manila clams are broadly equivalent in terms of their *E. coli* accumulation. It is recommended that the practice of periodically sampling clams for comparative purposes is continued.

12. The classification listings for Manila clams (*Tapes philippinarum*) and native clams (*Tapes decussatus*) in the Poole Harbour production area should in future be given as ‘*Tapes* spp’.

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List of Abbreviations

ADAS	Agricultural Development and Advisory Service
ANOVA	Analysis of Variance
BMPA	Bivalve Mollusc Production Area
BWD	Bathing Waters Directive
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CEH	Centre for Ecology and Hydrology
CFU	Colony forming unit
CSO	Combined Sewer Overflow
DWF	Dry Weather Flow
EA	Environment Agency
E. coli	*Escherichia coli*
EC	European Community
EU	European Union
FSA	Food Standards Agency
GMT	Greenwich Mean Time
HW	High Water
ha	Hectare
JNCC	Joint Nature Conservation Committee
km	Kilometre
LFA	Local food authority
LW	Low water
m^3/day	Cubic metres per day
m^3/s	Cubic metres per second
ml	Millilitres
mm	Millimetres
MPN	Most probable number
NGR	National Grid Reference
OS	Ordnance Survey
ppt	Parts per thousand
PS	Pumping Station
PBC	Poole Borough Council
PHC	Poole Harbour Commissioners
RMP	Representative Monitoring Point¸
Ro/Ro	Roll on/ Roll off (ferry)
SPA	Special Protection Area
SPS	Sewage pumping station
SRD	Sewage related debris
SSFC	Southern Sea Fisheries Committee
SSO	Storm sewer overflow
STW	Sewage treatment works
SWD	Shellfish Waters Directive
UKHO	United Kingdom Hydrographic Office
UV	Ultra violet
WEMS	Wessex Environmental Microbiology Service

Glossary

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 areas	A system for grading harvesting areas based on levels of bacterial indicator organisms (usually *E. coli* or faecal coliforms) in shellfish (in European Union).
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.
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.
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.
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 at 37°C. Usually, but not exclusively, associated with the intestines of warm-blooded animals and birds.
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 a skewed data such as one following a lognormal distribution.
Secondary	Treatment applied to breakdown and reduce the amount of

Treatment	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.
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 dilute sewage.
Waste water	Any waste water but see also “sewage”.

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Nigel Selby	Poole Borough Council
Sally Porter	Poole Harbour Commissioners
Simon Pengelly	Southern Sea Fisheries Committee

APPENDIX A: Shoreline survey record form

SHORELINE SURVEY RECORD FORM			
1	**Bed ID**		
2	**Bed Name/Coordinates**		
3	**Production Area**	Poole Harbour	
4	**Area of Bed(s)**		
5	**SWD Flesh Point**		
6	**SWD Water Point**	**North** SZ 03510 89208 (50:42:9.008N 1:57:5.979W) **South** SZ 01627 86649 (50:36.80998N 3:26.41187W)	
7	**BWD Sampling Point(s)**		
8	**Applicant's Details**	**Name** Poole Borough Council **Address** Northmead House, 30-32 Northmead Drive, Creekmoor, POOLE, BH17 7RP (01202 261700	
9	**Cefas Officer(s)**	Richard Acornley	
10	**Local Authority Officer(s)**	Nigel Selby **Address** as above (as above	
11	**Date/time of survey:**	11/03/2009	
12	**Extent of Survey Area**	South Side of Poole Harbour (See attached map)	
13	**Map/Chart References**	UKHO Admiralty Chart 2611 *Poole Harbour and Approaches:* Imray Chart 2300.5 *Poole Harbour* OS Explorer OL15: *Purbeck and South Dorset*	
14	**Predicted Tides**	Poole Cleavel Point (50°40'N, 2°00'W) Totaltide (GMT) HW 09:28 (2.1m) LW 16:41 (0.2m) See attached chart	
15	**Weather Forecast**		
16	**Air temperature**	N/A	
17	**Wind**		

18	**Precipitation**	Dry
19	Sunshine Duration	N/A
20	Air Pressure	N/A
21	Rivers/streams/springs	SY 96660 84770 Corfe River at Sharford Bridge (**PHOTO 6**). Agricultural catchment. Corfe Castle STW. SZ 02341 84467 Brands Bay. Small stream draining Studland Heath (receives Studland STW). **PHOTO 5.** SZ 01700 84502 Greenland tidal stream draining Newton Heath plantation (**PHOTO 7**) SZ 01306 84764 Goathorn small stream draining Newton Heath plantation
22	River flows (observed)	N/A
23	River flows (gauged)	N/A
24	Discharges (observed)	SY 92153 87819 North Bridge Wareham SPS (14268) River Piddle d/s roadbridge. No overflow to watercourse. SY 92304 87173 Abbots Quay CSO Wareham (**PHOTO 2**) SY 99748 86201 Ower House discharge 1 (no flow) SY99798 86208 Ower House discharge 2 (**PHOTO 1**) flowing, sewage effluent smell. Volume <1m^3/day no gross contamination/SRD. SY 95080 81670 Glebe Farm Church Knowle PS (14266) on tributary of Corfe River. No overflow found. SY 92686 87256 SE Wareham SPS (14259) No discharge point found.
25	Boats/Port	Houseboat (junk) moored opposite Round Island pier. On site over 2 years (Nigel Emery). Boats moored on River Frome at Wareham (**PHOTO 4**).
26	Animals observed	**BIRDS/OTHER WILDLIFE** Shipstal point, Arne approx. 10 Sika deer feeding on/close to beach (**PHOTO 3**), Black headed gull, oystercatcher, red breasted merganser Opposite Round Island pier, 50+ brent geese, shelduck, 10 redshank, small flock teal, mallard SY 97987 87515 Nr Round Island 45 brent geese, 14 shelduck, 2 teal, 10 wigeon, 3 avocet, cormorant, curlew. Deer hoof prints and faeces on shore.

		SY 97761 87297 39 godwits Ower Bay 100 brent geese, redshank, 2 shelduck, little egret, gulls **LIVESTOCK** Slepe Farm Cattle in field next to road Wytch Farm Cattle on farm and in surrounding fields (**PHOTO 8**) Greenland Farm Horses Cattle in valley to west of path to Ower Quay
27	Strand line SRD	None
28	Samples Taken	None
29	Water Appearance	N/A
30	Bivalve Harvesting Activity	2 pump dredgers off Fitzworth Point Bait dredgers off Arne
31	Production	N/A
36	Land Use Adjacent to Harvesting Area	Plantation, heathland, improved pasture
38	Topography Adjacent to Harvesting Area	Lowland
39	Other comments	Brands Bay is outside of regulated fishery (no close season) and harvesters claim clams have been taken from this site to get round regulations (NE)


Photo 1: Discharge at Ower Quay


Photo 2: Abbots Quay CSO Wareham


Photo 3: Sika deer at Arne


Photo 4: River Frome at Wareham


Photo 5: Stream at Brands Bay


Photo 6: Corfe River at Sharford Bridge


Photo 7: Stream near Greenlands


Photo 8: Cattle near Wych Farm

APPENDIX B SAMPLING PLAN

General Information

Production Area	Poole
Cefas Main Site Reference	M054
Cefas Area Reference	FDR 3734
Ordnance Survey 1:25,000 map	Explorer OL15 Purbeck and South Dorset
Admiralty Chart	2611 Poole Harbour and Approaches

Shellfisheries

Species/Culture	Cockles (*Cerastoderma edule*)/Wild & farmed Mussels (*Mytilus* spp.)/ Wild & farmed Native clams (*Tapes decussatus*)/ Wild & farmed Pacific oysters (*Crassostrea gigas*)/Farmed Native Oysters (*Ostrea edulis*)/Farmed Manila clams (*Tapes philippinarum*)/Wild & Farmed
Harvesting seasons	Cockle (wild): May to January Clam (wild): October to March within regulated fishery Farmed species: All year

LFA details

Local Food Authority	Poole Borough Council
Address	Environmental and Consumer Protection Services Unit 1, New Fields Business Park, Stinford Road, Poole BH17 0NF
E-mail	environment@poole.gov.uk
Telephone	01202 261700
Sampling Officer	Nigel Selby

Monitoring points and frequency of sampling
See maps and table below

Requirement for review
The competent authority will review this sampling plan within six years or in light of any obvious known changes in sources of pollution of human or animal origin (e.g. following a sewerage improvement scheme).

Following liaison with the Local Authority the sampling plan was been updated in February 2012

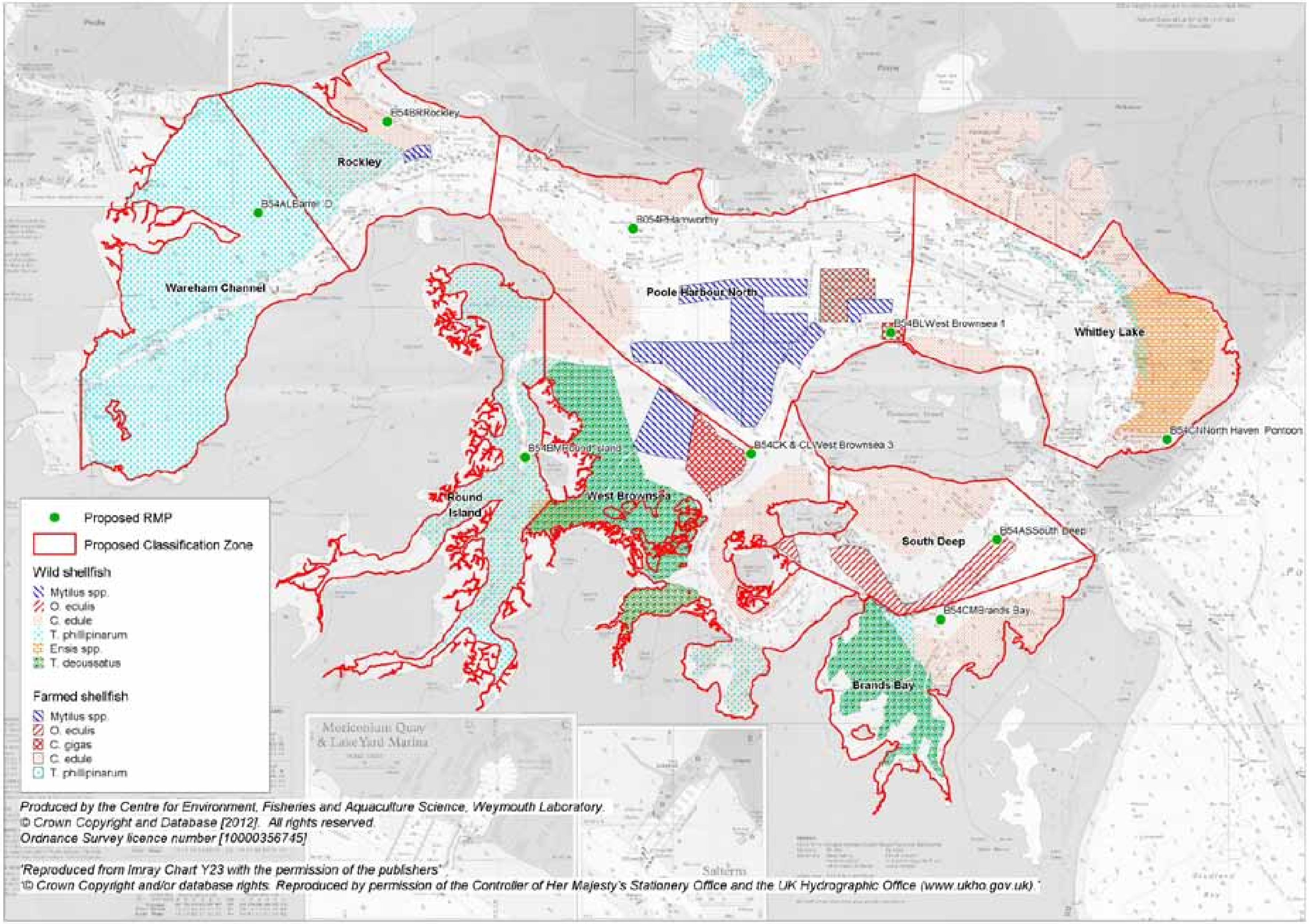

***Figure B1** Recommended classification zones and RMPs in Poole Harbour (February 2012).*

Table B1 *Representative Monitoring Points (RMP) and frequency of sampling for Poole Harbour (February 2012)*

RMP	**RMP Name**	**Species**	**NGR**	**WGS84**		**Collection method**	**Sample Frequency**	**Classified zone**	**Classified species (current classification)**
				Latitude	**Longitude**				
B54AL	Barrel 'O'	*Mytilus* spp.	SY 9619 8977	50°42.45'N	2°03.32'W	Sample bag	Monthly	Wareham Channel	*Tapes* spp. (C) *C. edule* (C)
B54BR	Rockley	*Mytilus* spp.	SY 9734 9058	50°42.89'N	2°02.34'W	Sample bag	Monthly	Rockley	*C. edule* (B) *Mytilus* spp. (B) *Tapes* spp. (B-LT)
B054P	Hamworthy	*Mytilus* spp.	SY 9952 8963	50°42.38'N	2°00.49'W	Sample bag	Monthly	Poole Harbour North	*Tapes* spp. (B-LT) *Mytilus* spp. (B-LT) *C. edule* (B-LT)
B54BL	West Brownsea 1	*C. gigas*	SZ 0181 8871	50°41.88'N	1°58.54'W	Sample bag	Monthly	Poole Harbour North	*C. gigas* (B-LT) *O. edulis* (B-LT)
B54CN	North Haven Pontoon	*Mytilus spp.*	SZ 0426 8776	50°41.37'N	1°56.46'W	Sample bag	Monthly	Whitley lake	*C. edule*(B-LT)
B54BM	Round Island	*Mytilus* spp.	SY 9856 8760	50°41.28'N	2°01.30'W	Sample bag	Monthly	Wych Lake	*C. edule* (B-LT) *Tapes* spp. (B-LT)
B54CK (C. gigas) B54CL (mussels)	West Brownsea 3 (W. Cardinal)	*C. gigas*& *Mytilus* spp.	SZ 0057 8763	50°41.30'N	1°59.60'W	Sample bag	Monthly	SW Brownsea Island	*Tapes* spp. (B-LT) *C. edule* (B-LT) *C. gigas* (B-LT) *O. edulis* (B-LT)
B54AS	South Deep RELAY AREA	*Mytilus* spp.	SZ 0275 8687	50°40.89'N	1°57.75'W	Sample bag	Monthly	South Deep	*O. edulis* (B-LT)
B54CM	Brands Bay	*Mytilus* spp.*	SZ 0225 8616	50°40.51'N	1°58.17'W	Sample bag	Monthly	Brands Bay	*C. edule* (B-LT) *Tapes* spp. (B-LT)