Centre for Environment Fisheries & Aquaculture Science

www.cefas.defra.gov.uk

EC Regulation 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SANITARY SURVEY REPORT

Lymington Estuary

December 2013

Food Standards Agency

Cover photo: Lymington River oyster holding area

© Crown copyright 2013

This document/publication is also available on our website at:

http://www.cefas.defra.gov.uk/our-science/animal-health-and-food-safety/food-safety/sanitary-surveys/england-and-wales.aspx

Contacts

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

Simon Kershaw
Food Safety Group
Cefas Weymouth Laboratory
Barrack Road
The Nothe
Weymouth
Dorset
DT4 8UB

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

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

Karen Pratt,
Hygiene Delivery Branch
Enforcement and Delivery Division
Food Standards Agency
Aviation House
125 Kingsway
London
WC2B 6NH

☎ +44 (0) 207 276 8970
✉ shellfishharvesting@foodstandards.gsi.gov.uk

Statement of use

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

Revision history

Version	Details	Prepared by	Approved by	Approval date
1	Draft for internal consultation	Alastair Cook	Simon Kershaw	11/08/2013
2	Draft for client/consultee comment	Alastair Cook	Simon Kershaw	14/08/2013
3	Final	F Vogt /S Kershaw	Simon Kershaw	31/01/2013

Consultation

Consultee	Date of consultation	Date of response
New Forest District Council	14/08/2013	20/11/2013 via FSA
Southern IFCA	14/08/2013	20/08/2013 via FSA
Environment Agency	14/08/2013	none
Southern Water	14/08/2013	12/09/2013 via FSA
Shellfish Association of Great Britain	14/08/2013	12/09/2013 via FSA
Food Standards Agency	14/08/2013	04/10/2013 and 20/11/2013

Dissemination

Food Standards Agency, New Forest District Council. The report is available publicly via the Cefas website.

Recommended Bibliographic Reference

Cefas, 2013. Sanitary survey of Lymington Estuary. Cefas report on behalf of the Food Standards Agency, to demonstrate compliance with the requirements for classification of bivalve mollusc production areas in England and Wales under EC regulation No. 854/2004.

Contents

1. Introduction

1.1. Legislative Requirement

Filter feeding, bivalve molluscan shellfish (e.g. mussels, clams, oysters) retain and accumulate a variety of microorganisms from their natural environments. Since filter feeding promotes retention and accumulation of these microorganisms, the microbiological safety of bivalves for human consumption depends heavily on the quality of the waters from which they are taken.

When consumed raw or lightly cooked, bivalves contaminated with pathogenic microorganisms may cause infectious diseases in humans (e.g. Norovirus-associated gastroenteritis, Hepatitis A and Salmonellosis). Infectious disease outbreaks are more likely to occur in coastal areas, where bivalve mollusc production areas (BMPAs) are impacted by sources of microbiological contamination of human and/or animal origin.

In England and Wales, fish and shellfish constitute the fourth most reported food item causing infectious disease outbreaks in humans after poultry, red meat and desserts (Hughes *et al.*, 2007).

The risk of contamination of bivalve molluscs with pathogens is assessed through the microbiological monitoring of bivalves. This assessment results in the classification of BMPAs, which determines the level of treatment (e.g. purification, relaying, cooking) required before human consumption of bivalves (Lee and Younger, 2002).

Under EC Regulation 854/2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption, sanitary surveys of BMPAs and their associated hydrological catchments and coastal waters are required in order to establish the appropriate representative monitoring points (RMPs) for the monitoring programme.

The Centre for Environment, Fisheries & Aquaculture Science (Cefas) is performing sanitary surveys for new BMPAs in England and Wales, on behalf of the Food Standards Agency (FSA). The purposes of the sanitary surveys are to demonstrate compliance with the requirements stated in Annex II (Chapter II paragraph 6) of EC Regulation 854/2004, whereby 'if the competent authority decides in principle to classify a production or relay area it must:

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

b) examine the quantities of organic pollutants which are released during the different periods of the year, according to the seasonal variations of both human and animal populations in the catchment area, rainfall readings, waste-water treatment, etc.;

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

d) establish a sampling programme of bivalve molluscs in the production area which is based on the examination of established data, and with a number of samples, a geographical distribution of the sampling points and a sampling frequency which must ensure that the results of the analysis are as representative as possible for the area considered.'

EC Regulation 854/2004 also specifies the use of *Escherichia coli* as an indicator of microbiological contamination in bivalves. This bacterium is present in animal and human faeces in large numbers and is therefore indicative of contamination of faecal origin.

In addition to better targeting the location of RMPs and frequency of sampling for microbiological monitoring, it is believed that the sanitary survey may serve to help target future water quality improvements and improve analysis of their effects on shellfish hygiene. Improved monitoring should lead to improved detection of pollution events and identification of the likely sources of pollution. Remedial action may then be possible either through funding of improvements in point sources of contamination or as a result of changes in land management practices.

This report documents the information relevant to a sanitary survey undertaken for native oysters (*Ostrea edulis*) within the Lymington estuary. The area was prioritised for survey in 2013-14 by a shellfish hygiene risk ranking exercise of existing classified areas.

1.2. Area description

The Lymington estuary is situated on the south coast of England, west of Southampton Water and north of the Isle of Wight. Its location is shown in Figure 1.1. It covers a total area of 2.4km², 80% of which is intertidal (Futurecoast, 2002) and consists of one main channel which discharges into the western Solent.

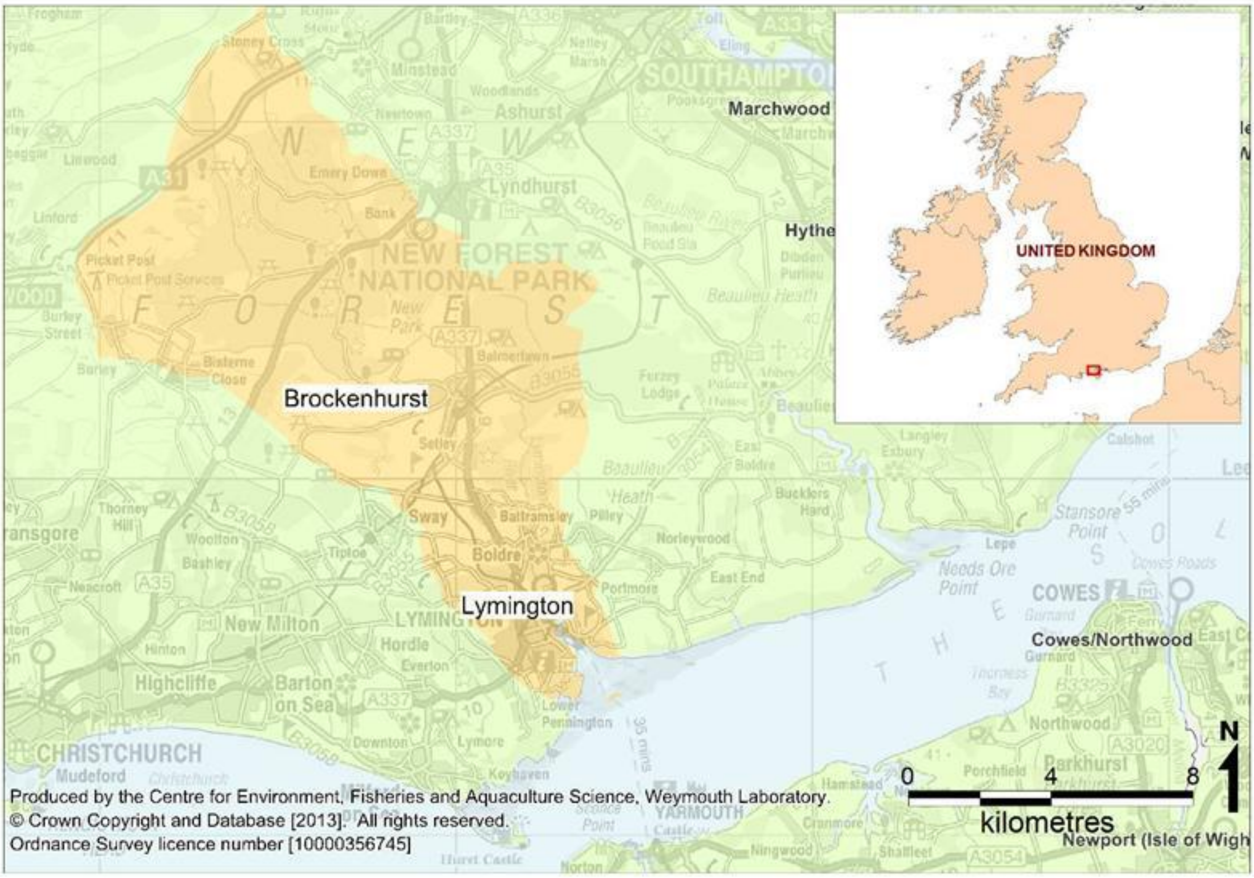


Figure 1.1: Location of Lymington Estuary

Lymington estuary has been recognised as an important area for its estuarine habitats and wildlife. It comprises of saltmarsh, intertidal mudflats, lagoons, reedbeds and smaller areas of sand and shingle beds. These features attract significant populations of internationally and nationally important birds and an abundance of other wildlife. Consequently, the Lymington estuary is protected by several international and national environmental legislations including: Special Protection Area (SPA), Special Site of Scientific Interest (SSSI), Area of Outstanding Natural Beauty (AONB), Site of Importance for Nature Conservation (SINC), National Nature Reserve (NNR) and falls within the Solent Special Area of Conservation (SAC).

Boating is an important pastime within the Lymington estuary, with many recreational activities taking place such as yachting, dinghy sailing, windsurfing and canoeing. A commercial fishing fleet also operates from the estuary. Oysters are harvested from the Solent and held in the Lymington Estuary, where they are stored in the short term before being sent to the Blackwater on the east coast of England or abroad for relaying. There are no naturally occurring oysters within the Lymington estuary at the current time.

1.3. Catchment

The Lymington estuary has a catchment area of approximately 132 km^2. Land cover within it is shown in Figure 1.2.

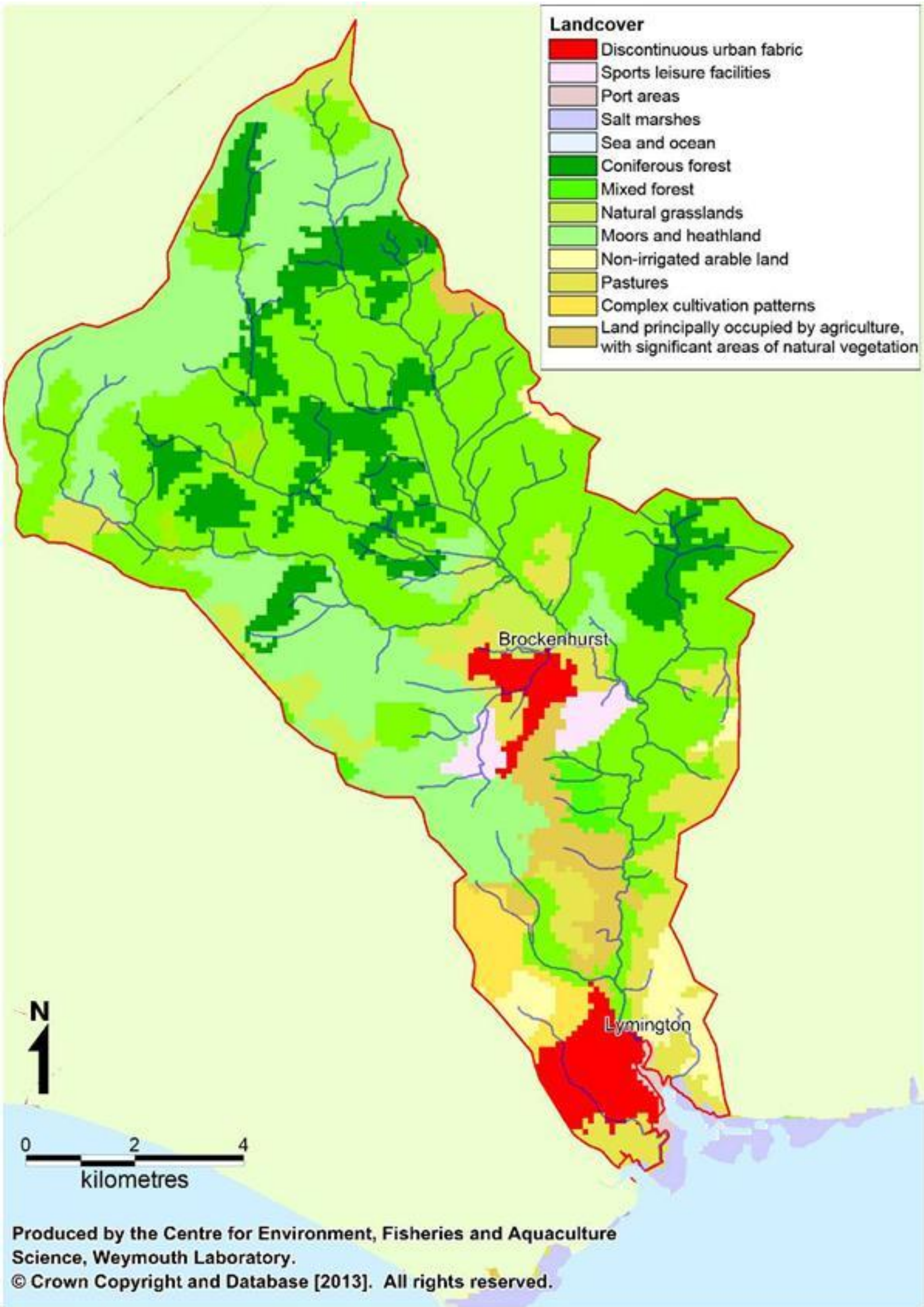


Figure 1.2: Landcover in Lymington estuary catchment area

There is a marked division in land use between the upper and lower catchment. The upper catchment forms part of the New Forest National Park hence the landcover is predominantly woodland while the lower catchment is more urbanised. The urbanised areas represent the towns of Lymington and Brokenhurst. The lower catchment also supports pasture, crops and sports and leisure facilities.

Different land cover types will generate differing levels of contamination in surface runoff. Highest faecal coliform contribution arises from developed areas, with intermediate contributions from the improved pastures and lower contributions from the other land types (Kay *et al*. 2008a). The contributions from all land cover types would be expected to increase significantly after marked rainfall events, particularly for improved grassland which increase up to 100 fold.

There is difference in the geology between the upper and lower catchment. The upper reaches are underlain with Bracklesham and Barton clays and the lower catchment with Bembridge clays and marls (West, 2007). Both are relatively impermeable, so river discharge is likely to respond rapidly to rainfall.

2. Recommendations

Only one small area around the town slipway (on the west bank) requires continued classification for native oysters only. It is therefore recommended that the classified zone be reduced to reflect this (Figure 3.1) and to prevent any possible expansion into more contaminated areas.

It is used as a short term holding site for oysters dredged from the Solent area, the season for which runs from November to February inclusive. There is the possibility that they will continue to be held outside this period, so it is recommended that a year round classification is maintained. The Lymington River is likely to be the principle source of contamination to the upper estuary. There are also very high volumes of pleasure boat traffic here, mainly in the summer. There are three intermittent sewage discharges to the west bank in very close proximity to the fishery. Two of these have event monitoring, and were recorded as spilling for less than 0.2% of the time in recent years. The third is unmonitored. Additionally, there are several relatively small private sewage discharges to the east bank of the upper reaches of the estuary. Microbiological monitoring suggests there is a fairly steep gradient of increasing contamination towards the head of the estuary in the relatively confined upper reaches. It is therefore recommended that the RMP be located on the west bank, just upstream of the town slipway.

The species sampled should be native oysters. If these become difficult to source, Pacific oysters may represent a suitable surrogate, assuming there are no biosecurity (e.g. disease related movement restrictions) or other reasons, including conservation requirements, why such a practice should not be adopted. A deployment bag[1] of Pacific oysters to be used for sampling purposes as a surrogate species when insufficient stocks of native oysters are present and for this a tolerance of 10m applies. It will have to be suitably secreted and secured, which may necessitate a slight change in the specified RMP location. Sampled stock should have been held *in situ* to equilibrate for at least two weeks prior to sampling. Sampling should be undertaken monthly on a year round basis to maintain a full classification.

---

[1] Shellfish deployed in a suitable bag fixed to a buoy/anchor to guarantee stock is available in the desired sampling location.

3. Sampling Plan

3.1. General Information

Location Reference

Production Area	Lymington River
Cefas Main Site Reference	M083
Ordnance survey 1:25,000 map	Explorer OL22
Admiralty Chart	5600.4

Shellfishery

Species/culture	Native oysters (*Ostrea edulis*)	Short term relay
Seasonality of harvest	Closed season for native oysters from source fishery (March-October inclusive). Closed season may be extended for 2013/14.	

Local Enforcement Authority

Name	New Forest District Council
Address	Town Hall Avenue Road Lymington Hampshire SO41 9ZG
Environmental Health Officer	Dale Bruce
Telephone number ☎	02380 285000
E-mail	dale.bruce@nfdc.gov.uk

3.2. Requirement for Review

The Guide to Good Practice for the Microbiological Monitoring of Bivalve Mollusc Harvesting Areas (EU Working Group on the Microbiological Monitoring of Bivalve Mollusc Harvesting Areas, 2010) indicates that sanitary assessments should be fully reviewed every 6 years, so this assessment is due a formal review in 2019. The assessment may require review in the interim should any significant changes in sources of contamination come to light.

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

Classification zone	RMP	RMP name	NGR	Latitude & Longitude (WGS84)	Species	Growing method	Harvesting technique	Sampling method	Tolerance	Frequency	Comments
Lymington waterfront	B083D	Town Slipway	SZ 3280 9561	50º45.55'N 01º32.18'W	Native oysters	Short term storage of stocks dredged from the Solent area	Hand	Hand (deployment bag)	10m	Monthly	RMP location may require slight adjustment to find suitably concealed and secure location. Should stocks of native oysters become difficult to source, Pacific oysters may be used as a surrogate, assuming there are not reasons why the introduction of this species should not occur (e.g. biosecurity).

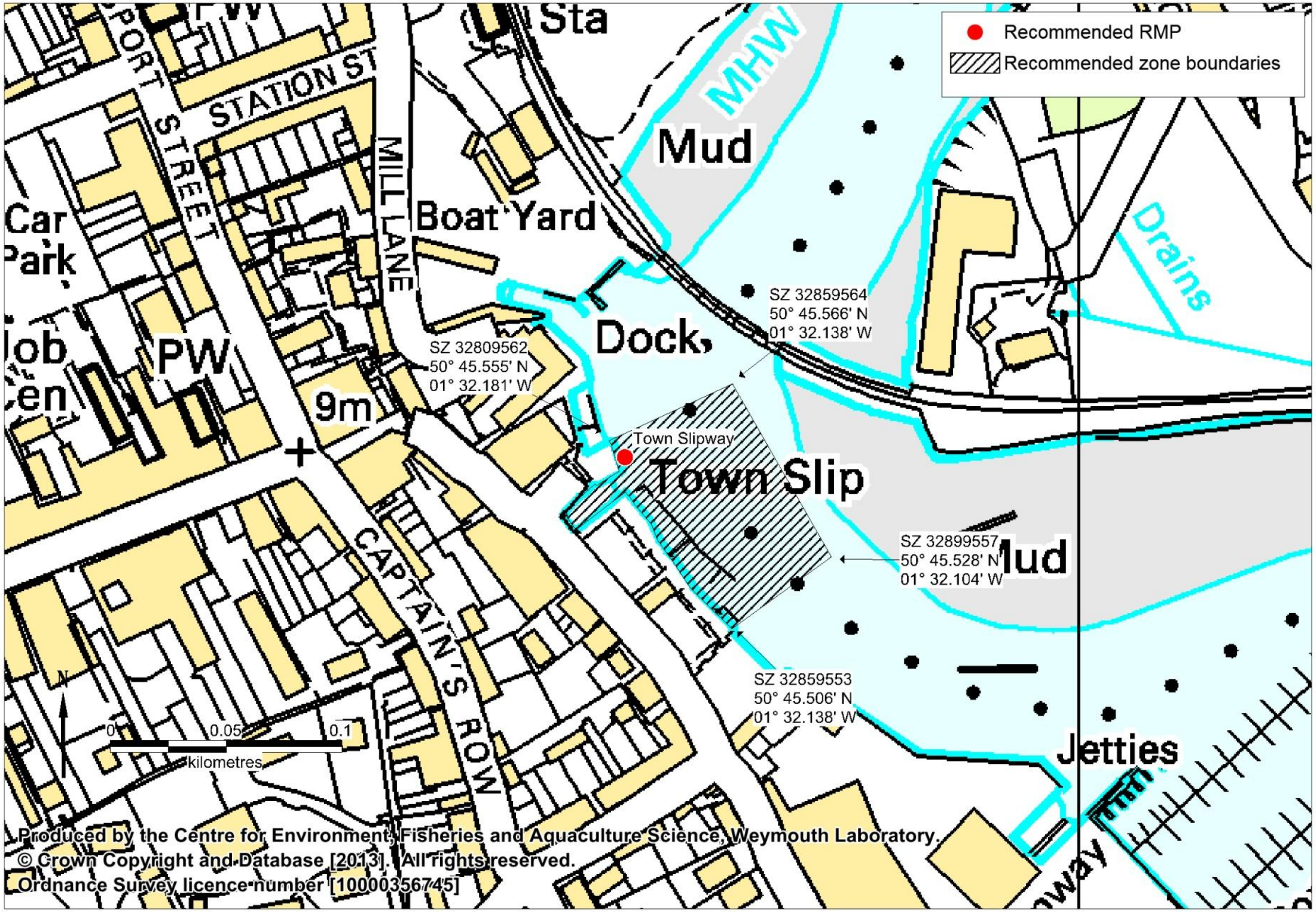


Figure 3.1: Recommended zoning and monitoring arrangements (native oysters)

4. Shellfisheries

4.1. Species, location and extent

The Lymington estuary is currently classified for the harvest of native oysters only. It does not actually support an exploitable, naturally occurring population of this species, but is used as a temporary holding area for oysters taken from elsewhere in the Solent area. This somewhat unusual arrangement allows the operators to store oysters in the short term for subsequent sale when sufficient stock has been accumulated to merit sending a batch. Stocks are held in bags under buoys just off the town slipway, and then moved onto the slipway shortly before collection (Figure 4.1). The volumes which pass through the site are uncertain, but have declined to quite low levels in recent years.

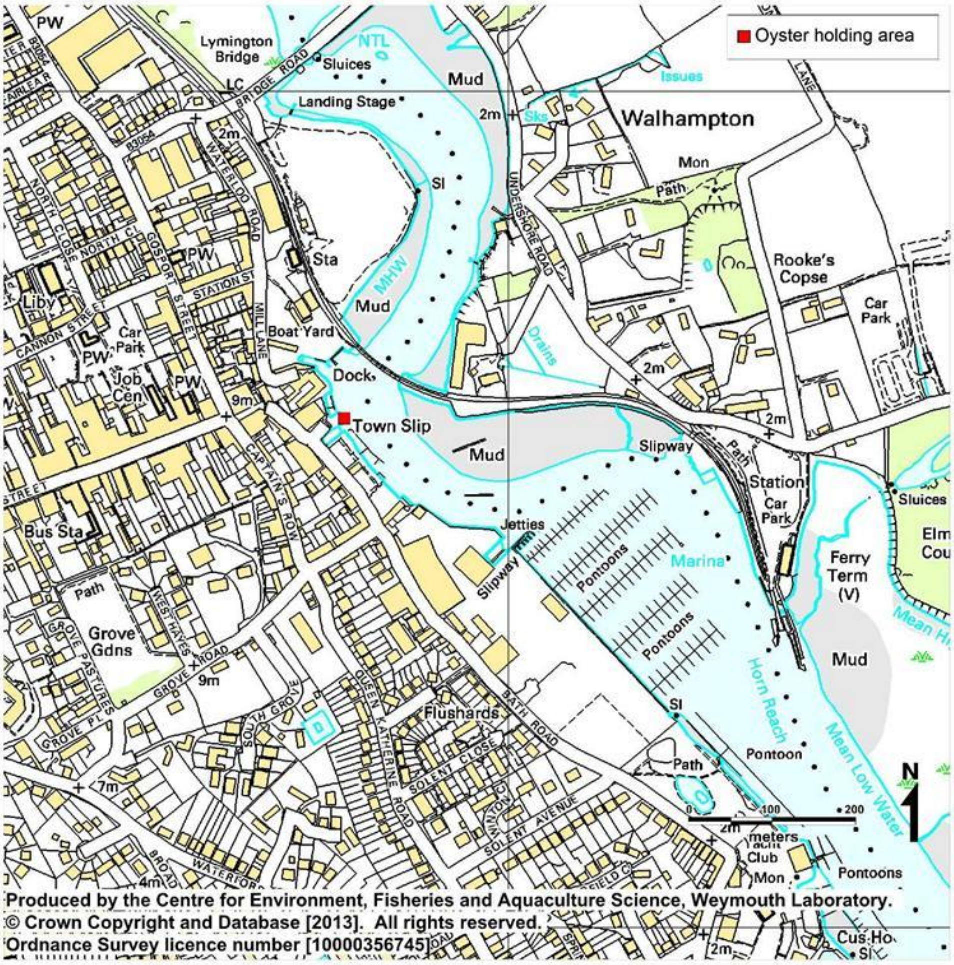


Figure 4.1: Location of oyster holding site

4.2. Growing Methods and Harvesting Techniques

Wild stocks are collected by dredge from various areas in the Solent, and held in bags by the town slipway until a batch is ready for export. As they are held for only a few days, this cannot be considered as on-growing or even relaying. Stock held in the river should not originate from unclassified or prohibited areas or areas of a poorer classification.

4.3. Seasonality of Harvest, Conservation Controls and Development Potential

The harvest of oysters within the fisheries that supply the holding area is only allowed from 1st November through to the end of February. Native oysters are also subject to other byelaws including a minimum landing size of 70mm.

As they are only held for a short period it is unlikely that there is much if any stock present outside of the local oyster harvesting season. The seasonal pattern of the use of the holding area closely mirrors that of the Solent fishery; a major peak in activity on the first week of the season followed by much more limited activity, if any, through to February. No stock was present at the time of shoreline survey (June 2013).

The Southern IFCA will probably close the native oyster fishery in the Solent for the 2013/14 season on conservation grounds, and only open Portsmouth, Langstone and Chichester harbours for four weeks in November. This, together with the poor status of stocks in the Solent area (e.g. Palmer and Firmin, 2011) is likely to result in further reductions of volumes passing through this site.

4.4. Hygiene Classification

Most classified areas in the vicinity of the Solent, from which stocks held at Lymington originate, are class B, although there are some class C areas, for example within Chichester and Langstone Harbours. The Lymington estuary has held a C classification since it was first classified in 1997, and is classified as a harvesting area. This arrangement was established by the LEA in order to gain some control over the use of the area. A ‘C’ classification of the Lymington River is considered to offer a suitable level of public health protection. This information is appropriately included in registration documents, the use of which is monitored and controlled by the New Forest District Council. The area classified is considerably larger than the area used for holding oysters.

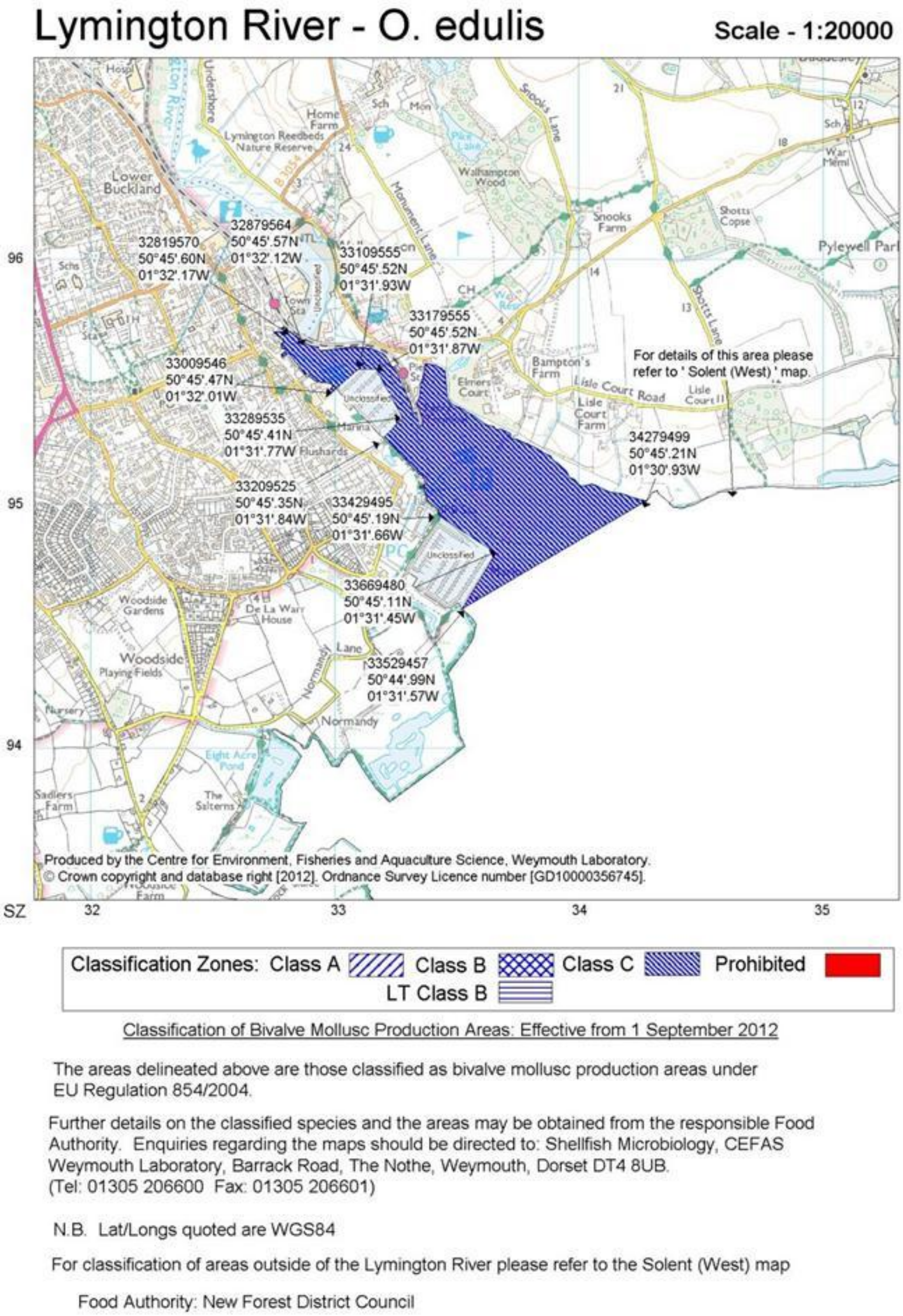


Figure 4.2: Current native oyster classification for Lymington Estuary

Table 4.1: Criteria for classification of bivalve mollusc production areas.

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

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

5. Overall Assessment

5.1. Aim

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

5.2. Shellfisheries

The Lymington estuary is used as a short term holding area for native oysters dredged from the Solent area while batches of a sufficient size are assembled for export. They are held in bags in the channel off the town slipway, and then moved onto the town slipway whilst awaiting collection. They are then sent to either France or the Blackwater on the east coast of England, although it must be noted that there are no designated relay areas at the latter location. They are only held in the estuary for a few days, and the seasonal pattern is typically a peak of activity in early November, and possibly occasional activity through the rest of the season which continues through to the end of February.

The operation considered in this sanitary survey is therefore not strictly a fishery or even a relay area. It has held a C classification since it was first classified, and the vast majority of the grounds where the stock may originate from are class B, although there are some small areas of class C. The C classification the site holds does provide suitable public health protection as the oysters cannot be sold without being relayed for at least 2 months. The area currently classified greatly exceeds that required, so can be significantly reduced to reflect the actual location of the fishery and exclude potentially more contaminated areas.

The provision of native oysters to sample outside of the dredging season requires planning, and if the stock held back for sampling purposes is removed or dies off, sourcing them becomes problematic. Pacific oysters have been identified as a suitable surrogate from a hygiene monitoring perspective (Younger & Reese, 2011) and would probably be much easier to source at certain times of the year. However, there may be biosecurity or other potential issues associated with holding this species within the Lymington estuary which would require investigation before such a strategy may be adopted.

5.3. Pollution Sources

Freshwater Inputs

All rivers and streams will carry some bacteriological contamination and so will require consideration in this assessment. The catchment area draining directly into the Lymington estuary is approximately 132 km². The vast majority of this area is drained by the Lymington River and tributaries, which discharges to the head of the estuary via tidal gates. Its catchment is mainly forested, with some agricultural and urban land in its lower reaches. Additionally, there are two other small watercourses draining to the estuary further downstream, one to the east bank by the ferry terminal, and one to the west bank in the outer reaches.

The catchment is underlain by impermeable clays so river flow is likely to be dominated by run-off, which will result in a quick response to rainfall and large fluctuations in river flow. Flow gauging records from the Lymington River at Brockenhurst show an average discharge of 1.18m^3/sec, with a maximum of just over 26 m^3/sec recorded during the period 2003 to 2013. Flows were highest on average from November to March, but there was significant variation on a day to day basis, and high flow events were recorded in all months of the year. The tidal gates through which it discharges to the estuary shut when river levels are lower than the tidal level thereby limiting discharge of the river to lower states of the tide. Therefore its impacts will be most pronounced around low water, in the upper reaches at least. No bacteriological testing data was available for this watercourse.

During the shoreline survey, the unnamed watercourse discharging to the east shore by the ferry terminal was sampled and measured. The bacterial loading it was carrying at the time was 2.3×10^{11} *E. coli* cfu/day, and its discharge was measured as 0.11 m^3/sec, which is minor in relation to the Lymington River. The small watercourse discharging to the west bank of the lower estuary was not sampled or measured as it was considered too far away from the fishery to be of significance.

It is therefore concluded that there is likely to be an overall gradient of decreasing levels of runoff borne contamination from the sluice gates down to the estuary mouth. There may also be minor localised hotspots where the smaller watercourses join the estuary. The magnitude of this is likely to fluctuate significantly from day to day and season to season in response to rainfall and other factors, such as evaporation in warmer weather or groundwater levels at the time.

Human Population

The total resident population within the Lymington estuary catchment was approximately 30,000 at the time of the last census (2011). The main concentrations were at Lymington, on the west bank of the estuary, and at Brockenhurst on the banks of the middle reaches of the Lymington River. Most of the rest of the catchment lies within the New Forest which is sparsely populated.

The catchment receives influxes of visitors, mainly during the summer months drawn by local attractions. Lymington, for example, is a centre for recreational boating and the New Forest draws significant numbers of tourists, with Brockenhurst being a main centre for visitors. The exact numbers of visitors are not known, but it is assumed that there is a significant population increase during the summer months, therefore sewage works will be serving larger populations during the summer holiday season.

Sewage Discharges

There are four continuous water company discharges to the area all of which discharge to the Lymington River or tributaries thereof above the tidal limit. The largest of these is Brockenhurst STW, which discharges 9 km above the tidal limit and provides tertiary treatment for a consented dry weather flow of 1233 m^3/day. The tertiary treatment it provides is biological, and for nutrient rather than bacterial removal. Boldre STW provides secondary treatment for a dry weather flow of 200m^3/day and discharges 3.5 km upstream of the tidal limit. Bank STW provides reedbed treatment for a dry weather flow of 38 m^3/day. There is also a small sewage works at Passford House, which discharges biologically treated sewage, 3.6 km above the tidal limit. No details on volumes discharged were available. Sewage from the town of Lymington is treated at the Pennington STW, which provides UV treatment and discharges via long sea outfall to the western Solent, so its impacts on the estuary are likely to be negligible. Therefore, the continuous water company sewage works discharging to the catchment are relatively minor, and will all be carried to the fishery via the Lymington River.

There are also nine intermittent discharges associated with the water company sewer networks, which may discharge untreated or screened sewage in the event of heavy rainfall overwhelming the sewers or an emergency such as a blockage or power cut. Five of these discharge to the upper reaches of the Lymington estuary, three discharge to the Lymington River upstream of the tidal limit and one discharges to the watercourse which drains to the west bank of the outer estuary. The five discharging to the upper reaches of the Lymington estuary are of most potential significance to the fishery. Two of these (Station Street No. 1 and Bridge Road) discharge at the tidal limit, and three (Station Street No. 2, High Street, and Lymington Slipway) discharge in very close proximity to the town slipway where the fishery is located. Spill records were available for three of these (High Street, Lymington Slipway and Station Street No. 1) and none had spilled for more than 0.2% of the time for the period January 2008 to March 2012. As the other two are unmonitored, it is difficult to assess their impacts aside from noting their location and potential to discharge untreated sewage. Spill records were also available for Brockenhurst STW overflow, which only spilled for 0.4% of the period.

Intermittent discharges create issues in management of shellfish hygiene however infrequently they spill. Their impacts are not usually captured during a years' worth of monthly shellfish monitoring from which the classification is derived, as they only operate occasionally. Thus when they do have a significant spill, heavily contaminated shellfish may be harvested under a better classification than the levels of *E. coli* within them may merit. A reactive system alerting relevant parties to spill events in real time may therefore convey better public health protection. The very low spill frequency from the monitored outfalls near the fishery suggests that spills are likely to be a very rare event, from these outfalls at least.

Although the vast majority of properties are served by water company sewerage infrastructure, there are also a number of private discharges. Where specified, these are generally treated by small treatment works such as package plants or septic tanks. The majority of these are small, serving one or two properties. Around half of these discharge to soakaway so should be of no impact if they are functioning correctly. The remainder discharge to watercourses (mainly the Lymington River and tributaries) or to the upper east bank of the estuary from the ferry terminal up to the tidal limit. There are 11 discharging to the latter area, of which three are consented to discharge over $5m^3$/day. The largest by far of these is the Elmers Court discharge, which is a package plant consented to discharge up to 115 m^3/day. There is also a potentially significant discharge (Walhampton School, consented to discharge up to 20 m^3/day) to the short watercourse which drains to the estuary behind the ferry terminal.

Overall, it is concluded that the majority of sewage discharged to the catchment will be carried to the estuary via the Lymington River. The series of private discharges along the eastern shore of the upper estuary will also contribute and there may be hotspots in the immediate vicinity of their outfalls. There are five intermittent discharges to the estuary, of which three are monitored and hardly spill at all. Some are in very close proximity to the fishery, one of which is unmonitored so it is difficult to make an assessment of its potential impact.

Agriculture

The majority of land within the hydrological catchment of the Lymington River is forested, with a relatively low proportion devoted to agriculture. Contamination of livestock origin will either be deposited directly on pastures by grazing animals, or collected from operations such as cattle sheds and poultry houses and spread on both arable land and pasture. This in turn will enter watercourses which will carry it to coastal waters. There are some pockets of pasture and arable land in the lower catchment, and the outer reaches of the estuary are flanked by saltmarsh backed by pastures. Most contamination of agricultural origin will therefore enter the estuary via the Lymington River, with the two smaller watercourses draining to the lower estuary also likely to be affected. There were 977 cattle, 1,373 sheep, 175,259 poultry and an undisclosed but small number of pigs within the catchment according to the 2010 agricultural census. Numbers of livestock are therefore low, and so their impacts are likely to be relatively minor.

Fluxes of agricultural contamination into the estuary will be highly rainfall dependent so are likely to fluctuate significantly from day to day. There will also be underlying seasonal variation, driven by numbers and distributions of livestock, the timing of applications of organic fertilizers, and rainfall and runoff levels. Numbers of sheep and cattle will increase significantly in the spring, with the birth of lambs and calves, and decrease in the autumn when animals are sent to market. During winter cattle may be transferred from pastures to indoor sheds, and at these times slurry will be collected and stored for later application to fields. Timing of these applications is uncertain, although farms without large storage capacities are likely to spread during the winter and spring. Poultry manure and sewage sludge may be spread at any time of the year. During the summer only, cattle and ponies are grazed on the reclaimed pastures within the Lymington-Keyhaven reserve. Therefore peak levels of contamination from grazing animals may arise following high rainfall events in the summer, particularly if these have been preceded by a dry period which would allow a build up of faecal material on pastures, or on a more localised basis if wet weather follows a manure application which may occur at any time of the year.

Boats

Boat traffic within the Lymington estuary is heavy, mainly consisting of pleasure craft such as yachts and cabin cruisers. It has two large marinas with about 1000 berths between them, around 230 further pontoon berths, and 500 resident's moorings. One of these marinas offers sewage pumpout facilities. There is also a ferry terminal with hourly sailings from May to September, and a small fishing fleet (~12 vessels) operates from the estuary. As such, overboard discharges from boats may be a significant contaminating influence here.

Commercial shipping is not permitted to make overboard discharges within 3 nautical miles of land so the ferries should be of no impact. Private vessels such as yachts, motor cruisers and fishing vessels of a sufficient size are likely to make overboard discharges from time to time. This may either occur when the boats are moored or at anchor, particularly if they are in overnight occupation, or while they are navigating through the estuary. Occupied yachts on pontoon berths may be less likely to make overboard discharges as facilities on land are easier to access. The areas that are at highest risk from microbiological pollution therefore include mooring areas and the main navigation routes through the estuary, i.e. the whole of the estuary including the oyster holding area. Peak pleasure craft activity is anticipated during the summer, so associated impacts are likely to follow this seasonal pattern. It is difficult to be more specific about the potential impacts from boats and how they may affect the sampling plan without any firm information about the locations, timings and volumes of such discharges.

Wildlife

The Lymington estuary includes intertidal mudflats, shingle banks, saltmarsh, reed beds and lagoons. These support wildlife populations which may be a contaminating influence at times. The most significant wildlife aggregation in terms of shellfish hygiene is likely to be overwintering waterbirds (waders and wildfowl). An average total count of 15,354 waterbirds was recorded over five winters up to 2010/11 in the North West Solent between Hurst Spit and Sowley. Some species (e.g. waders) prefer to forage on the intertidal mudflats, so will represent a diffuse source of contamination across these areas. Whilst they may represent a significant source of contamination to the estuary at times, their impacts will be widespread and so do not influence the sampling plan. Other species (e.g.

geese) graze the saltmarsh and reclaimed pastureland so their impacts will be carried into the estuary via watercourses and tidal creeks draining these areas.

Whilst most of the overwintering population migrate elsewhere in the summer, a much smaller population of resident and breeding birds will remain. Gulls and terns for example breed in the Lymington to Keyhaven Nature Reserve. No breeding sites have been recorded within the estuary itself however. Therefore, during the summer minor diffuse impacts associated with foraging seabirds may be anticipated within the estuary, but these will not influence the sampling plan.

The Solent area supports a combined population of about 25 harbour seals. They tend to forage in the eastern Solent and in Langstone and Chichester Harbours, but are occasionally sighted within the Lymington estuary. They are present year round but numbers peak in the summer. Given their small numbers and the large area they are likely to forage over, impacts are likely to be minor and unpredictable in spatial terms so will not be an influence on the sampling plan. No other wildlife species which have a potentially significant influence on levels of contamination within shellfish have been identified in the survey area.

Domestic animals

Dog walking takes place along coastal paths and represents a potential source of diffuse contamination to the near shore zone. However, as a diffuse source this will have little influence on the location of RMPs.

Summary of Pollution Sources

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

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

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

Red - high risk; orange - moderate risk; yellow - lower risk.

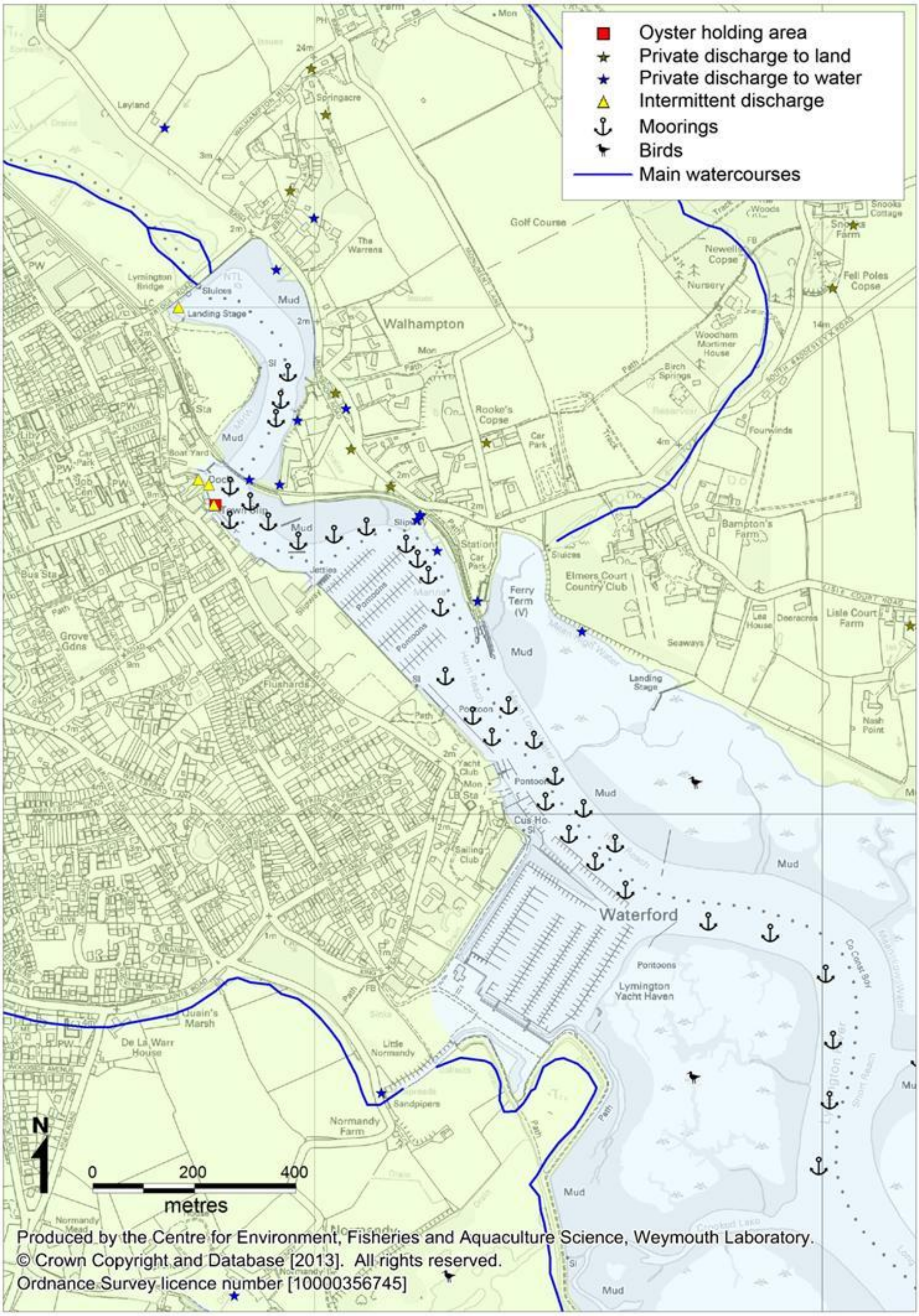


Figure 5.1: Summary of main contaminating influences

5.4. Hydrography

The Lymington estuary is a drowned river valley with one main channel of about 3km in length. The upper reaches in which the fishery is located consist of a relatively narrow and confined channel with a heavily developed shoreline. The lower reaches widen greatly, where the relatively narrow channel is flanked by large expanses of saltmarsh, drained by branching creeks feeding back into the main channel. The channel is about 2-4m in depth throughout most of its length but shallows to 1m in the very upper reaches where the oyster holding area is located. The shape of the estuary indicates that the dilution potential becomes lower towards its head.

The tidal regime is classed as mesotidal, with a tidal amplitude of 2.4m on spring tides. Double high waters occur at or near springs; on other occasions there is a stand which lasts about 2 hours within the Lymington estuary, and the ebb tide is shorter and faster moving than the flood tide. The estuary fills with water moving along the Solent shoreline in an easterly direction, so sources discharging to this shoreline to the west of the Lymington estuary may be carried into the estuary during the flood. Contamination from such sources will be subject to significant dilution during its passage into and up the estuary. Within the estuary tidal streams are bi-directional, moving up the estuary on the flood and back out on the ebb, with the main flows aligning with the main channel. As the main channel fills the tidal streams move up intertidal creeks and spread over the extensive intertidal saltmarsh/mudflats in the outer estuary. The reverse occurs on an ebb tide, so contamination from any sources discharging to the saltmarsh creeks will be carried out of the estuary without impacting on the upper reaches. Contamination from sources discharging to the shore in the upper estuary will move up and down the estuary with the tide along the bank to which it is discharged, becoming progressively more diluted. The main impacts from the private sewage discharges to the upper estuary will therefore be felt on the east bank.

Current velocities measured during spring tides were quite low, peaking at 0.57m/s in the outer estuary (Pylewell) and 0.20m/s in the inner estuary (Horn Reach). A very approximate estimate of maximum tidal excursion based on these measurements is in the order of 5 and 2km respectively on spring tides. Current velocities during neap tides in the Solent area are typically about half that experienced on spring tides. Therefore distant sources such as those in the lower estuary and outside it will be of little impact within the upper estuary.

Freshwater inputs may modify circulation patterns at times. The main freshwater input (Lymington River) discharges to the head of the estuary via tidal gates. The flow ratio (freshwater input:tidal exchange) is very low and the system as a whole is well mixed. However, the maximum flow ratio, suggests occasional stratification may occur on an ebb tide at high river flows. Therefore, density driven circulation is unlikely to modify tidal circulation within the estuary as a whole except at times of high river flows. Any such effects will be most marked in the upper reaches, and will result in a net seaward movement of less saline waters at the surface, and a corresponding return of more saline water at depth. Any stratification will entrain freshwater borne contamination in the surface layers.

Salinity at the tidal gates ranges from that of pure freshwater to that of undiluted seawater. Further down the estuary, where it starts to widen, salinity was usually approaching that of full strength seawater, with 20 ppt the minimum recorded. This indicates that there is a fairly steep gradient of increasing salinity in the upper estuary at times. Lower salinities were correlated with higher levels of faecal coliforms, so RMPs located at the upstream boundary of any classification zones will best capture contamination carried into the estuary by land runoff.

The sluice gates through which the Lymington River discharges close when tidal levels are higher than the water levels in the river. As there will be higher scope for dilution and the sluice will close around high water, significant fluctuations in salinity (and in levels of runoff borne contamination) are anticipated in the very upper reaches of the estuary across the tidal cycle.

Strong winds will modify surface currents. The prevailing south westerly winds will tend to push surface water in a north easterly direction. The inner reaches are more sheltered than the outer reaches. Exact effects on circulation are dependent on the wind speed and direction as well as state of the tide and other environmental variables, so are dynamic and difficult to predict. Where strong winds blow across a sufficient distance of water they may create wave action, and where these waves break contamination held in intertidal sediments may be resuspended. Such effects are likely to be minor, particularly in the inner estuary, although sediments are generally fine and easily disturbed. The washes created by boat traffic may also regularly disturb sediments.

5.5. Summary of Existing Microbiological Data

Lymington Estuary has been subject to some microbiological monitoring over recent years, deriving from Environment Agency water quality monitoring and shellfish flesh monitoring for hygiene classification purposes. Figure 5.2 shows the locations of the monitoring points referred to in this assessment.

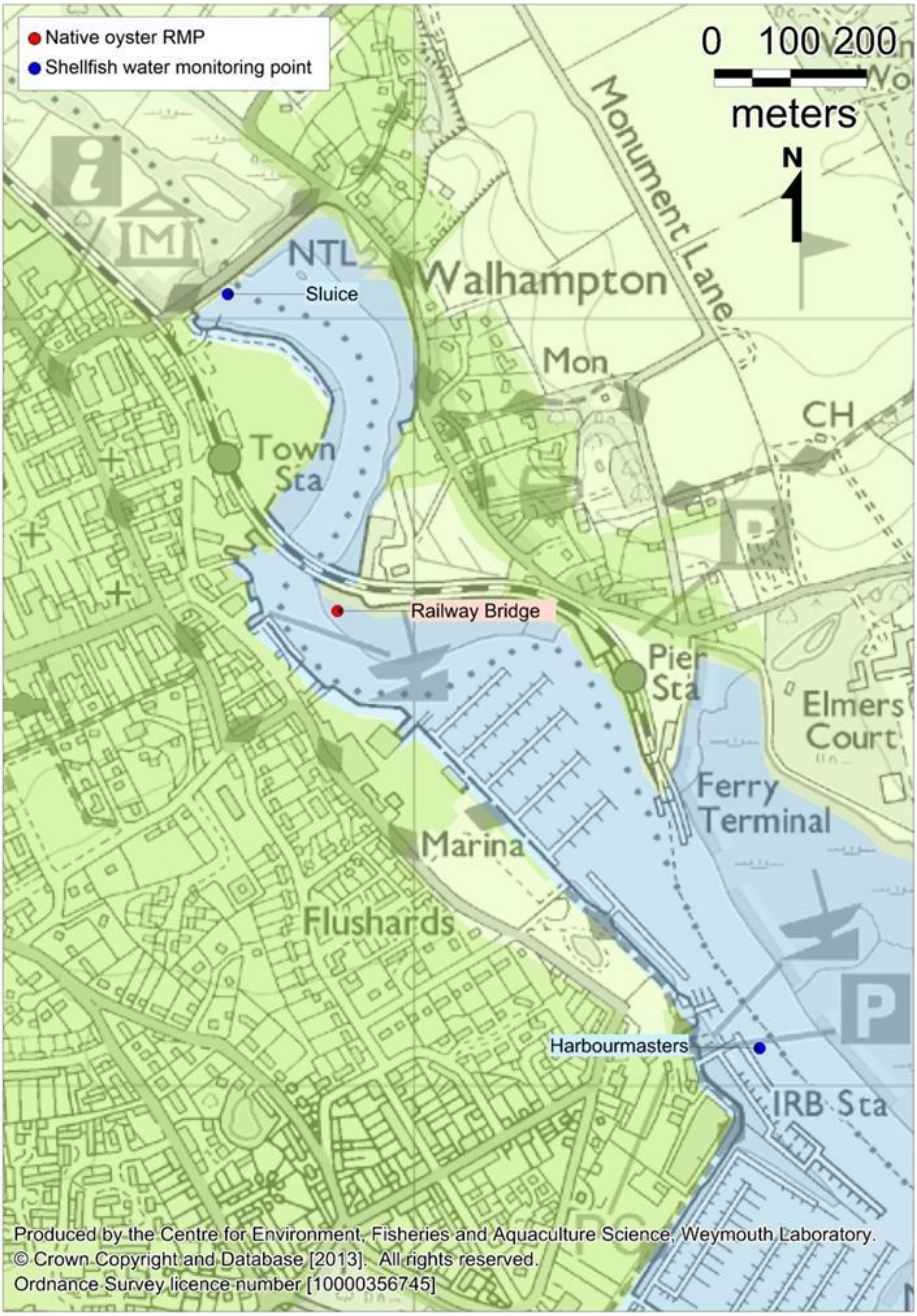


Figure 5.2: Microbiological sampling locations

At the two water sampling sites, 17 water samples were taken from each from November 2010 to March 2012 and tested for faecal coliforms. Results at Sluice were significantly higher than at Harbourmaster (geometric means of 3374 and 153 faecal coliforms/100ml respectively). Peak levels of 23,000 (Sluice) and 4,100 faecal coliforms/100ml (Harbourmaster) were recorded. This supports the previous assertion of a gradient of increasing contamination towards the head of the estuary. It also shows that levels of contamination in the upper estuary where the oyster holding site is located are high. There were no significant differences in faecal coliform concentrations between seasons, but a tendency for higher results in the winter was observed at Harbourmasters, and a tendency for lower results in the spring was apparent at Sluice. A significant influence of rainfall was detected at both sites, and this was stronger at the upstream site (Sluice). Significant negative correlations were found between salinity and faecal coliforms at both sites. The correlation was stronger at Harbourmaster, where faecal coliform results were much lower, and there was less freshwater influence.

Only one location has been sampled under the shellfish hygiene classification programme (Railway Bridge). This location was where the oyster holding site was initially located, although it has now moved to the opposite bank. A total of 108 samples were taken from this location and tested for *E. coli* from 2003 to the time of writing. The geometric mean result was 1768 *E. coli* MPN/100g, with 25% of results exceeding 4600 *E. coli* MPN/100g and 3% of results exceeding 46,000 *E. coli* MPN/100g. This indicates that levels of contamination are consistent with a C classification, and that prohibited level results are occasionally recorded. Over the years, results have been quite stable on average. Significant seasonal variation was found, with significantly higher levels of *E. coli* in summer than in winter. This does not reflect the seasonal patterns observed in water samples, and is probably influenced by increased metabolic rates in oysters during the warmer months of the year resulting in a greater uptake of indicator bacteria. Relatively weak correlations were found between levels of *E. coli* and rainfall compared to those observed with water samples. It is likely that large or abrupt decreases in salinity will reduce feeding rates in oysters, and this may be compounded by the lower temperatures experienced during the winter when river discharge rates are generally higher. A very weak correlation was found between levels of *E. coli* and the spring/neap tidal cycle, but no clear patterns were apparent when this data was plotted. No influence of the high/low tidal cycle was detected.

Appendices

Appendix I. Human Population

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

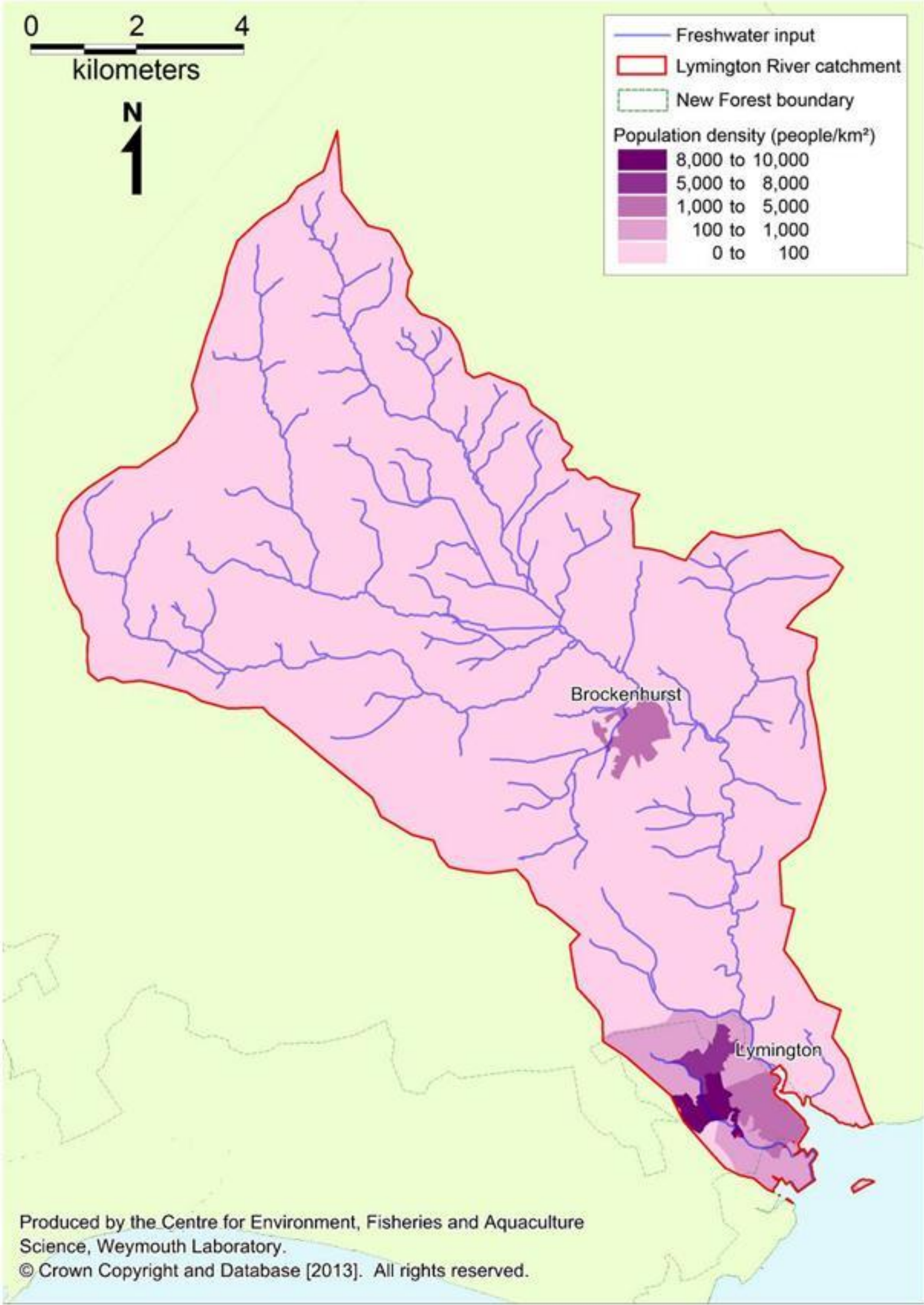


Figure I.1: Human population density in census areas in the Lymington River catchment.

Total resident population within the Lymington estuary catchment area was approximately 30,000 at the time of the last census. Figure I.1 indicates that population densities are highest at the south of the catchment around Lymington on the western side of the Lymington River, where it discharges to the Solent. The area directly adjacent to the river mouth has a population density of approximately 3,200 people per km² but parts of Lymington exceed 9,000 people per km². The town of Brockenhust represents a second population centre further inland. These areas are therefore at the most risk from contaminated urban runoff. Impacts from sewage will depend on the nature and locations of discharges associated with these settlements and are discussed in detail in Appendix VII. Approximately 96% of the catchment is covered by New Forest National Park, within which population densities are low (<100 persons per km^2 throughout).

Populations will increase during the summer months when tourists visit the New Forest and the Solent to take part in activities such as walking, cycling or sailing. The New Forest has a resident population of around 34,000 but attracted around 7 million day visitors in 2008 (Hampshire County Council, 2011) and around 1 million overnight stays annually (New Forest District Council, 2013). Although accurate tourism figures are not known for the majority of the catchment it is likely that the numbers are relatively high in the summer months due to it being situated within a national park and adjacent to the Solent. Therefore it can be assumed that there will be a significant seasonal variation of population levels in the catchment and the volumes of sewage received by treatment works serving the area is expected to fluctuate accordingly.

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

Details of all consented sewage discharges in the hydrological catchment of the Lymington River were taken from the most recent update of the Environment Agency national permit database (December 2012). These are mapped in Figure II.1.

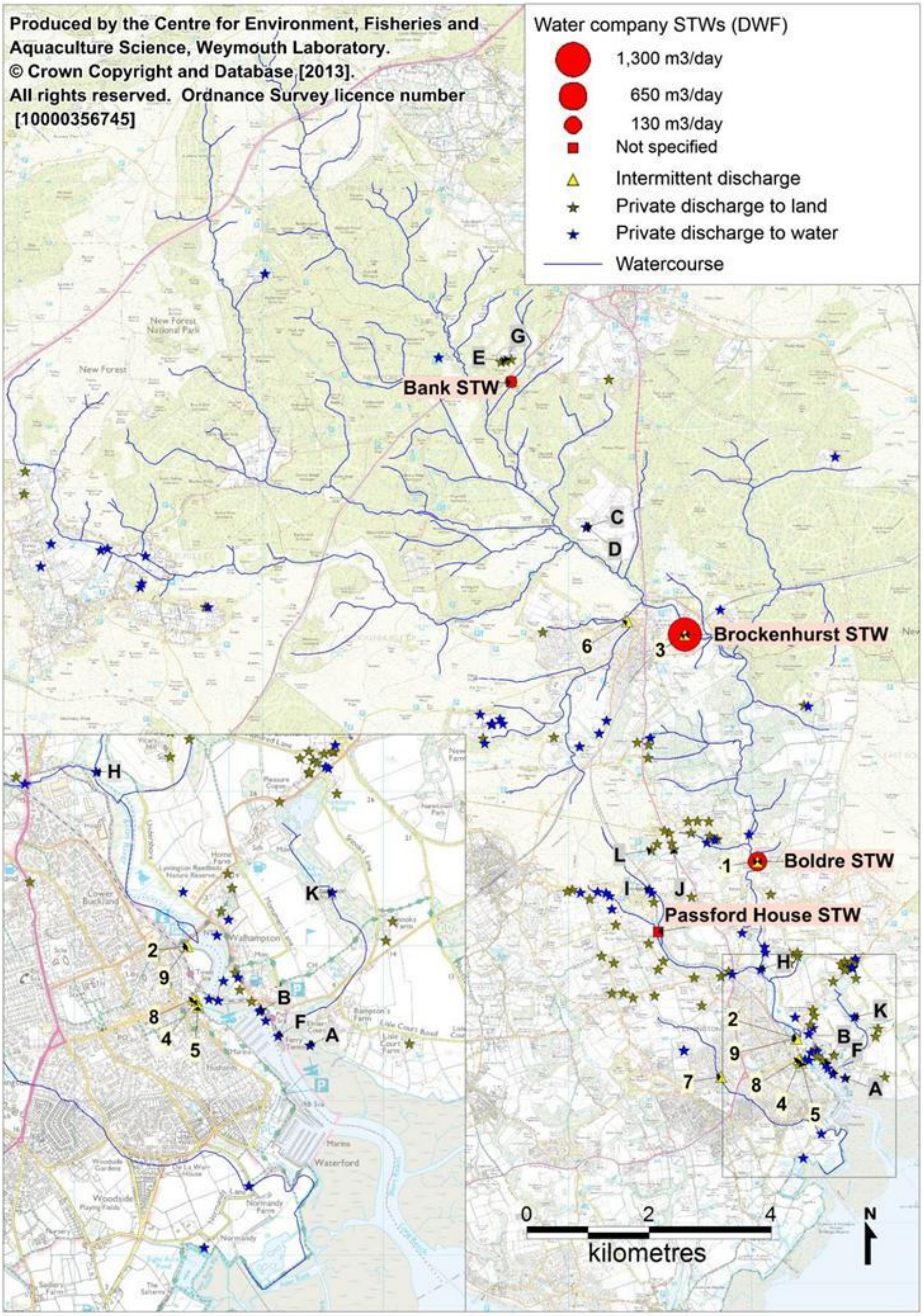


Figure II.1: Sewage discharges to the Lymington catchment
Data from the Environment Agency

There are four continuous water company discharges to the area, details of which are presented in Table II.1.

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

Name	NGR	Treatment	Dry weather flow (m3/day)	Receiving environment	Fluvial distance to tidal limit (km)
Bank STW	SU2810706707	Reedbed	38	Highland Water	15.5
Boldre STW	SZ3209098890	Secondary	200	Lymington River	3.5
Brockenhurst STW	SU3115802777	Tertiary biological	1233	Lymington River	9.0
Passford House STW	SZ3047097740	Secondary	Unspecified	Passford Water	3.6

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

Treatment Level	Flow			
	Base-flow		High-flow	
	n	Geometric mean	n	Geometric mean
Storm overflow (53)	-	-	200	$7.2x10^6$
Primary (12)	127	$1.0x10^7$	14	$4.6x10^6$
Secondary (67)	864	$3.3x10^5$	184	$5.0x10^5$
Tertiary (UV) (8)	108	$2.8x10^2$	6	$3.6x10^2$

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

All four discharge to the Lymington River or tributaries thereof, so any bacterial loading they generate will be carried into the estuary via this watercourse. There is likely to be some bacterial dieoff during this passage, particularly for the more distant discharges. The largest of these is Brockenhurst STW, which provides secondary treatment with an additional nutrient removal step. Boldre STW is smaller, but closer to the tidal limit and only provides secondary treatment. Bank STW provides treatment via reedbed, and is a small works a considerable distance from the tidal limit. There is also a small sewage works at Passford House, which discharges biologically treated sewage, 3.6km above the tidal limit. No details on volumes discharged were available

In addition to the continuous sewage discharges, there are several intermittent water company discharges associated with the sewerage networks also shown on Figure II.1. Details of these are shown in Table II.3, where discharges highlighted in yellow have spill even monitoring.

Table II.3: Intermittent discharges within the Chichester Harbour catchment

No.	Name	Grid reference	Receiving water	Type
1	Boldre STW	SZ3209098890	Lymington River	Settled storm
2	Bridge Road CSO	SZ3273096010	Lymington Estuary	Screened storm
3	Brockenhurst STW	SU3115802777	Lymington River	Settled storm, screened storm and emergency
4	High Street CSO	SZ3279095650	Lymington Estuary	Screened storm
5	Lymington Slipway CSO	SZ3280095610	Lymington Estuary	Screened storm
6	Manhole 86 Butts Lawn CSO	SU2996002820	Lymington River	Screened storm*
7	Southern Rd/Highfield Av CSO	SZ3149095380	Buckland Stream	Screened storm
8	Station Street No. 2 CSO	SZ3268095780	Lymington Estuary	Screened storm
9	Station Street No. 1 CSO	SZ3260095700	Lymington Estuary	Screened storm

Data from the Environment Agency

*Southern Water indicate that this discharge is likely to no longer be in operation, but this is not confirmed

For those without event monitoring it is difficult to assess their potential impacts aside from noting their location and potential to spill untreated sewage. Two are in very close proximity to the oyster holding area (Bridge Road and Station Street No. 1) of which only the latter is monitored. For those with event monitoring some spill summary statistics covering the period January 2008 to March 2012 are shown in Table II.4.

Table II.4: Summary of spill records, January 2008 to March 2012.

Discharge Name	No. events recorded	Mean event duration (hrs)	% of period active
Brockenhurst STW	7	19.3	0.4%
High Street CSO	10	0.3	<0.1%
Lymington Slipway CSO	2	0.5	<0.1%
Station Street No. 1 CSO	9	6.8	0.2%

Data from the Environment Agency

None of the monitored intermittent discharges spilled for a significant proportion of the time. This includes Station Street No. 1. Whilst they may very occasionally be of influence it is highly unlikely that their impacts would be captured via monthly monitoring.

Although the vast majority of the survey area is served by water company sewerage infrastructure, there are also a number of private discharges in the area. Where specified, these are generally treated by small treatment works such as package plants or septic tanks. Most of these are small, serving one or two properties. Details of the larger private discharges (>5m^3/day maximum permitted flow) are presented in Table II.5.

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

Ref.	Property served	Location	Treatment type	Max. daily flow (m^3/day)	Receiving environment
A	Elmers Court Country Club	SZ3352595360	Package plant	115	Lymington Estuary
B	Ferry Point	SZ3320095580	Unspecified	5.7	Lymington Estuary
C	Long Meadow Campsite	SU2928804357	Package plant	19.3	Lymington River trib.
D	New Park Manor Hotel	SU2929004361	Package plant	36.3	Lymington River trib.
E	P.G. Tutte Esq.	SU2797007070	Unspecified	8	Soakaway
F	Sealink Terminal	SZ3332095420	Unspecified	18	Lymington Estuary
G	Site 2 (4 properties)	SU2797007070	Unspecified	8	Soakaway
H	Southlands School	SZ3214097130	Unspecified	45	Lymington River
I	St. Dominics Priory	SZ3032098440	Unspecified	7	Passford Water
J	The Hobbler Public House	SZ3072099090	Unspecified	11	Soakaway
K	Walhampton School	SZ3367096350	Unspecified	20	Unnamed watercourse
L	Widden Close	SZ3035399081	Package plant	5	Soakaway

Data from the Environment Agency.

Three of the larger private works discharge direct to the estuary, and these are likely to be of most significance, particularly Elmers Court. All three discharge to the east bank in the upper reaches. Those discharging to soakaway are unlikely to be a significant influence assuming they are working properly. The majority of those discharging to watercourses feed into the main Lymington River, although there is a potentially significant discharge (Walhampton School) to a short watercourse which drains by the ferry terminal.

Appendix III. Sources and Variation of Microbiological Pollution: Agriculture

The majority of land within the hydrological catchment of the Lymington estuary is forested, with a relatively low proportion devoted to agriculture. There are some pockets of pasture and arable land in the lower catchment (Figure 1.2). The outer reaches of the estuary are flanked by saltmarsh backed by pastures. Table III.1 presents livestock numbers and densities for the catchment. These data were provided by Defra and are derived from the June 2010 census. Geographic assignment of animal counts in this dataset is based on the allocation of a single point to each farm, whereas in reality an individual farm may span the catchment boundary. Nevertheless, Table III.1 should give a reasonable indication of the numbers and types of livestock within the catchment.

Table III.1: Summary statistics from 2010 livestock census for the areas draining to Lymington estuary

Cattle		Sheep		Pigs		Poultry	
No.	Density (no/km^2)	No.	Density (no/km^2)	No.	Density (no/km^2)	No.	Density (no/km^2)
977	7.6	1373	10.7	*	*	175,259	1371

* Data suppressed to prevent disclosure of information about individual holdings.

Data from Defra

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

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

Farm Animal	Faecal coliforms (No./g wet weight)	Excretion rate (g/day wet weight)	Faecal coliform load (No./day)
Chicken	1,300,000	182	2.3×10^8
Pig	3,300,000	2,700	8.9×10^8
Human	13,000,000	150	1.9×10^9
Cow	230,000	23,600	5.4×10^9
Sheep	16,000,000	1,130	1.8×10^{10}

Data from Geldreich (1978) and Ashbolt et al. (2001).

There are small numbers of grazing animals (both sheep and cattle) within the catchment, as well as some poultry operations. Given the small numbers the overall impact of livestock farming is likely to be relatively small. Contamination of livestock origin will either be deposited directly on pastures by grazing animals, or collected from operations such as cattle sheds and poultry houses and spread on both arable land and pasture. This in turn will enter watercourses which will carry it to coastal waters. The majority of freshwater enters at the head of the estuary, although there are some smaller watercourses entering the lower reaches of the estuary. As the primary mechanism for mobilisation of faecal matter deposited on pastures into watercourses is via land runoff, fluxes of agricultural contamination into coastal waters will be highly rainfall dependent. Peak concentrations of faecal indicator bacteria in watercourses are likely to arise when heavy rain follows a significant dry period (the ‘first flush’).

During the summer, cattle and ponies are grazed on the reclaimed pastures within the Lymington-Keyhaven reserve (Hampshire County Council, 2013) but the intertidal saltmarsh is not grazed. There are also pastures adjacent to the outer east bank of the estuary. Runoff from the small watercourses draining these areas is likely to be subject to contamination from livestock. No livestock were recorded during the shoreline survey, although the two areas of pasture mentioned above were not visited.

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

Appendix IV. Sources and Variation of Microbiological Pollution: Boats

The discharge of sewage from boats is potentially a significant source of bacterial contamination of shellfisheries within the Lymington estuary. There is a large amount of boat traffic within Lymington Estuary, principally consisting of pleasure craft such as yachts and cabin cruisers. There are two marinas, a ferry terminal, and a small fishing fleet also operates from the estuary. Figure IV.1 presents an overview of boating activity derived from the shoreline survey, satellite images and various internet sources.

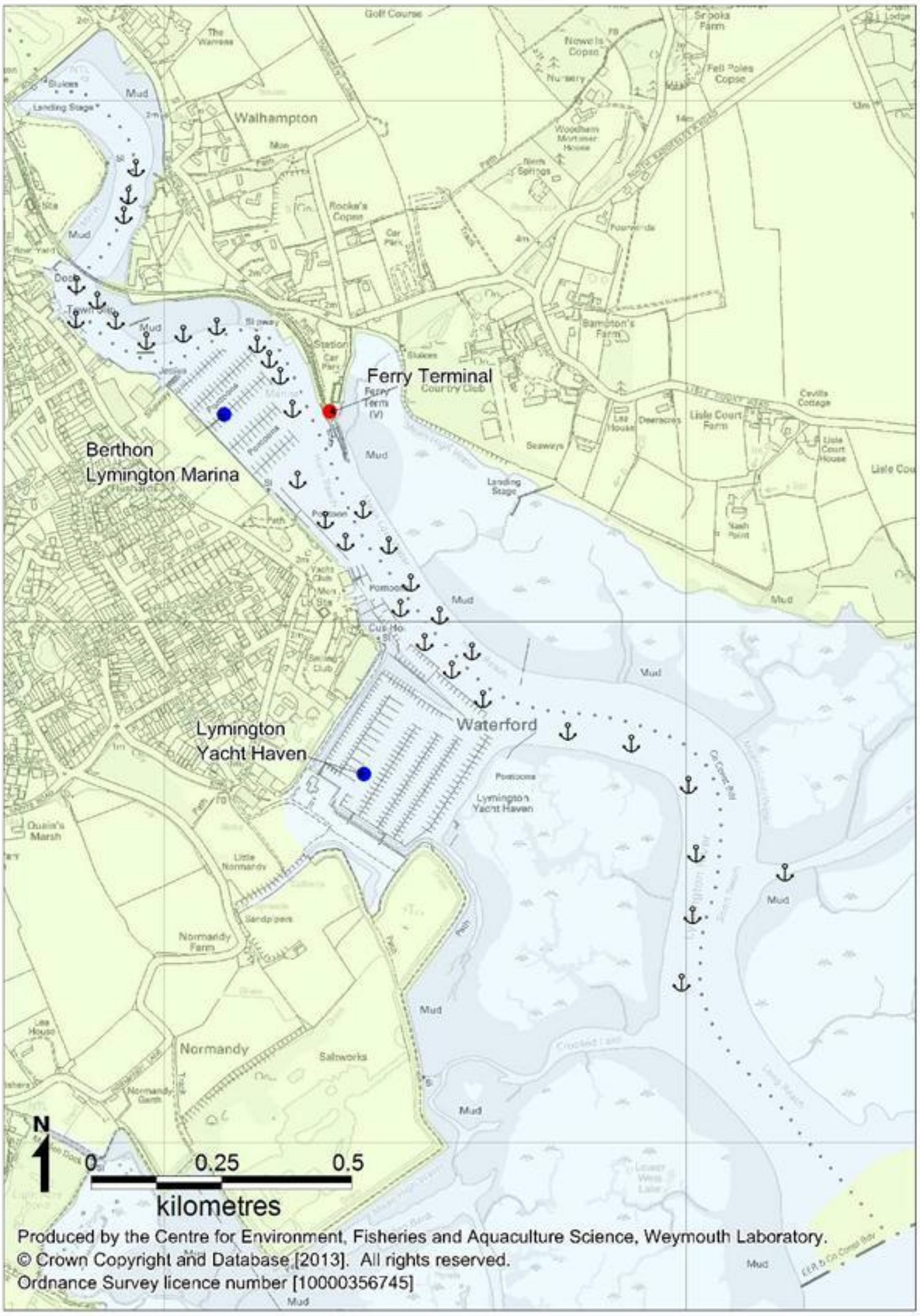


Figure IV.1: Boating activity in the Lymington Estuary

Figure IV.1 indicates that the Lymington Estuary is particularly crowded, with two large marinas and moorings present throughout the channel. The Marinas have around 1000 berths between them (Reeds Nautical Almanac, 2012) although sewage pumpout facilities are only available at one of them (Lymington Yacht Haven). There are also about 230 pontoon berths and 500 residents' moorings controlled by the Lymington Harbour Authority (Lymington Harbour Authority, 2013).

Around 12 small commercial fishing vessels operate out of the Old Town Quay north of Berthon Marina (Ports and Harbours of the UK, 2013). There are also numerous charter boats which can be hired for fishing and cruising trips. There are two sailing clubs which offer a variety of racing and courses for dinghies and the larger yachts and motor cruisers. There are no commercial ports within the Lymington Estuary, but there is a ferry terminal which connects Lymington with Yarmouth on the Isle of Wight. The Wightlink car ferry makes hourly crossings between 06:00 and 21:00, but only from May to September.

Merchant shipping vessels are not permitted to make overboard discharges within 3 nautical miles of land[2] so vessels associated with the ferry terminal should be of no impact. Smaller recreational boats are not large enough to contain onboard toilet facilities and therefore are therefore unlikely to make overboard discharges. Private vessels such as yachts, motor cruisers and fishing vessels of a sufficient size are likely to make overboard discharges from time to time. This may either occur when the boats are moored or at anchor, particularly if they are in overnight occupation, or while they are navigating through the relative calm of the estuary. Occupied yachts on pontoon berths may be less likely to make overboard discharges as this is somewhat antisocial in the crowded marina setting, and facilities on land are easier to access. The areas that are at highest risk from microbiological pollution therefore include mooring areas and the main navigation routes through the estuary. This is essentially the whole of the estuary. Peak pleasure craft activity is anticipated during the summer, so associated impacts are likely to follow this seasonal pattern. It is difficult to be more specific about the potential impacts from boats and how they may affect the sampling plan without any firm information about the locations, timings and volumes of such discharges.

[redacted]

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

Appendix V. Sources and Variation of Microbiological Pollution: Wildlife

The Lymington estuary encompasses a variety of habitats including, intertidal mudflats, shingle banks, saltmarsh, reed beds and lagoons. These features attract significant populations of birds and other wildlife. It is protected by several international and national environmental legislations including: Special Protection Area (SPA), Special Site of Scientific Interest (SSSI), Area of Outstanding Natural Beauty (AONB), Site of Importance for Nature Conservation (SINC), National Nature Reserve (NNR) and falls within the Solent Special Area of Conservation (SAC). The upper catchment forms part of the New Forest National Park.

The most significant wildlife aggregation in terms of shellfish hygiene is likely to be overwintering waterbirds (waders and wildfowl). Studies in the UK have found significant concentrations of microbiological contaminants (thermophilic Campylobacter, salmonellae, faecal coliforms and faecal streptococci) from intertidal sediment samples supporting large communities of birds (Obiri-Danso and Jones, 2000). An average total count of 15,354 waterbirds (wildfowl and waders) was reported over five winters up to 2010/11 in the North West Solent between Hurst Spit and Sowley (Holt *et al*., 2012). Studies undertaken in the winter of 2009/2010 revealed that shelduck are widely distributed throughout the Lymington Estuary with the highest densities recorded on the mudflats, seawards of the mouth. Black-tailed Godwit tend to favour the mudflats and lagoons of Lymington to Keyhaven Nature Reserve situated to the west of the mouth (Holt *et al*., 2011). The Lymington to Keyhaven Nature Reserve lagoons also support significant numbers of Brent Geese, Dunlin, Golden Plover, oystercatcher and a range of wildfowl (RSPB, 2013).

Waders, such as dunlin and oystercatchers forage upon shellfish and so will forage (and defecate) directly on any shellfish beds on the intertidal. They may tend to aggregate in certain areas holding the highest densities of bivalves of their preferred size and species, but this will probably vary from year to year. Contamination via direct deposition may be patchy, with some shellfish containing high levels of *E. coli* while others a short distance away are unaffected. At high tide waders are likely to frequent the saltmarsh and the perimeter of the estuary. Due to the diffuse and spatially unpredictable nature of contamination from wading birds it is difficult to select specific RMP locations to best capture this, although they may well be a significant influence during the winter months. Grazers such as geese and ducks will mainly frequent the grassland and saltmarsh, where their faeces will be carried into coastal waters via runoff into tidal creeks or through tidal inundation. Therefore RMPs within or near to the drainage channels from saltmarsh areas will be best located to capture contamination from this source.

Birds such as gulls and terns and relatively small numbers of waders remain in the area to breed in the summer, but the majority migrate elsewhere outside of the winter months. Bird numbers and potential impacts on the hygiene status of the fisheries are therefore much lower during the summer. Approximately 1.2% of the UKs nationally important, breeding little tern's population frequent the lagoons of Lymington to Keyhaven Nature Reserve as well as numerous other species of birds such as black headed gulls, sandwich terns and redshank (RSPB, 2013). The JNCC Seabird 2000 census recorded 4 pairs of Mediterranean Gulls on the mudflats to the east of the Lymington mouth (Mitchell *et al*, 2004). These seabirds are likely to forage widely throughout the area so inputs could be considered as diffuse, but are likely to be most concentrated in the immediate vicinity of the nest sites. Their faeces will be carried into coastal waters via runoff from their nesting sites or via direct deposition to the adjacent intertidal.

A group of up to 25 harbour seals live in the Solent area. They are more frequently sighted in the eastern Solent, in particular at their haul out locations in Langstone and Chichester Harbours (The Wildlife Trusts' South East Marine Programme, 2010). Occasionally seals are sighted in the Lymington Estuary (Hampshire & Isle of Wight Wildlife Trust, 2011) however, these are infrequent and given the large area they are likely to forage over impacts are likely to be minor, and unpredictable in spatial terms, but will peak during the summer, and be at its lowest during the autumn.

Appendix VI. Meteorological Data: Rainfall

The Brockenhurst weather station, received an average of 829 mm per year between 2003 and 2012. Figure VI.1 presents a boxplot of daily rainfall records by month at Brockenhurst.

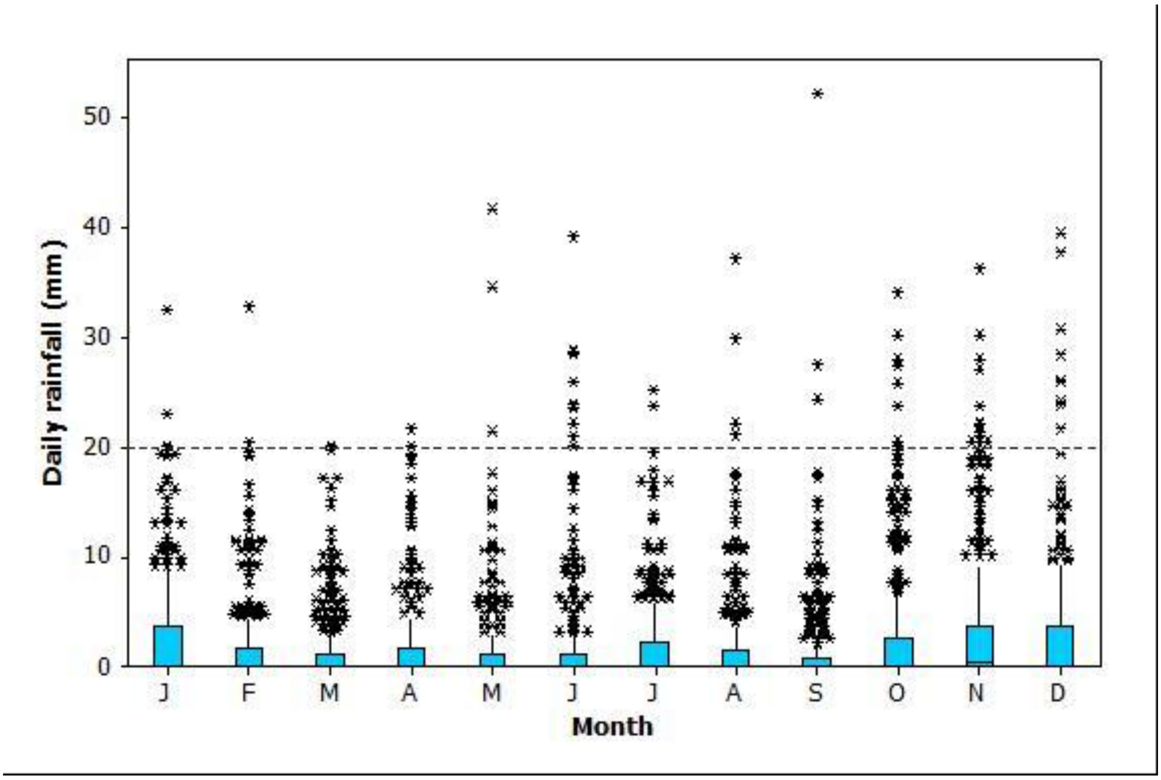


Figure VI.1: Boxplot of daily rainfall totals at Brockenhurst, January 2003 to December 2012.
Data from the Environment Agency

Rainfall records from Brockenhurst, which is representative of conditions in the Lymington Estuary catchment indicate relatively low seasonal variation in average rainfall. Rainfall was lowest on average in September and March and highest on average in November. Daily totals of over 20mm were recorded on 1.6% of days and 51% of days were dry. High rainfall events (>20mm) were recorded in all months.

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

Appendix VII. Meteorological Data: Wind

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

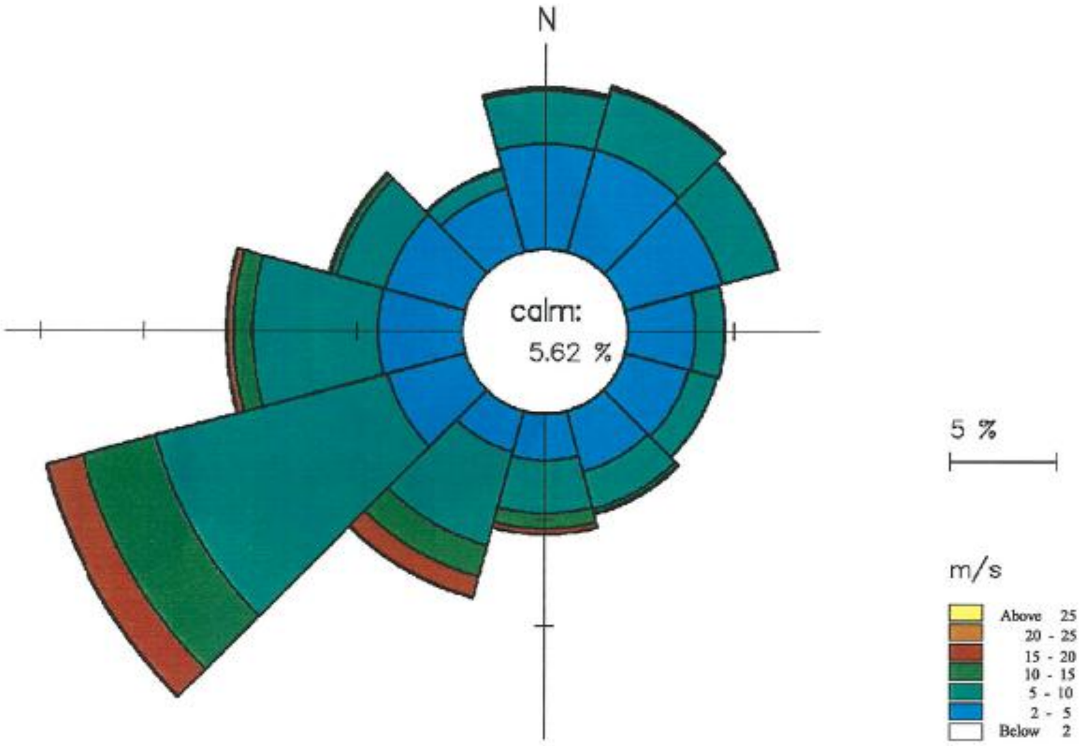


Figure VII.1: Wind Rose for Southampton Water Produced by ABPmer, 2007.

The prevailing wind direction is from the south west and the strongest winds usually blow from this direction (Figure VII.1). A higher frequency of north easterly winds occurs during spring. Lymington Estuary faces south east and is therefore relatively sheltered from prevailing winds. The Isle of Wight situated south of the Lymington Estuary also provides a considerable amount of protection from the south westerly winds. Winds from the south east, although less frequent will tend to be funnelled up the estuary as a consequence of the surrounding land and narrowing of the estuary upstream.

Appendix VIII. Hydrometric Data: Freshwater Inputs

The catchment area draining directly into the Lymington estuary, as estimated by topography, is approximately 132 km^2 (Figure 5.1). Above Brockenhurst three tributaries; the Highland Water, Blackwater and Oberwater converge to form the Lymington River which is the main freshwater input. A smaller tributary, the Weir joins the main river further south, on the western side. These drain mainly forested areas. The Lymington River then flows through a mix of forest, heathland and grassland and some urban areas in the lower catchment before discharging to the head of the estuary via tidal flap gates. These gates shut when river levels are lower than the tidal level in the estuary (Solomon, 2010) thereby limiting discharge of the river to lower states of the tide. There are two much smaller watercourses draining directly to the estuary downstream of the fishery.

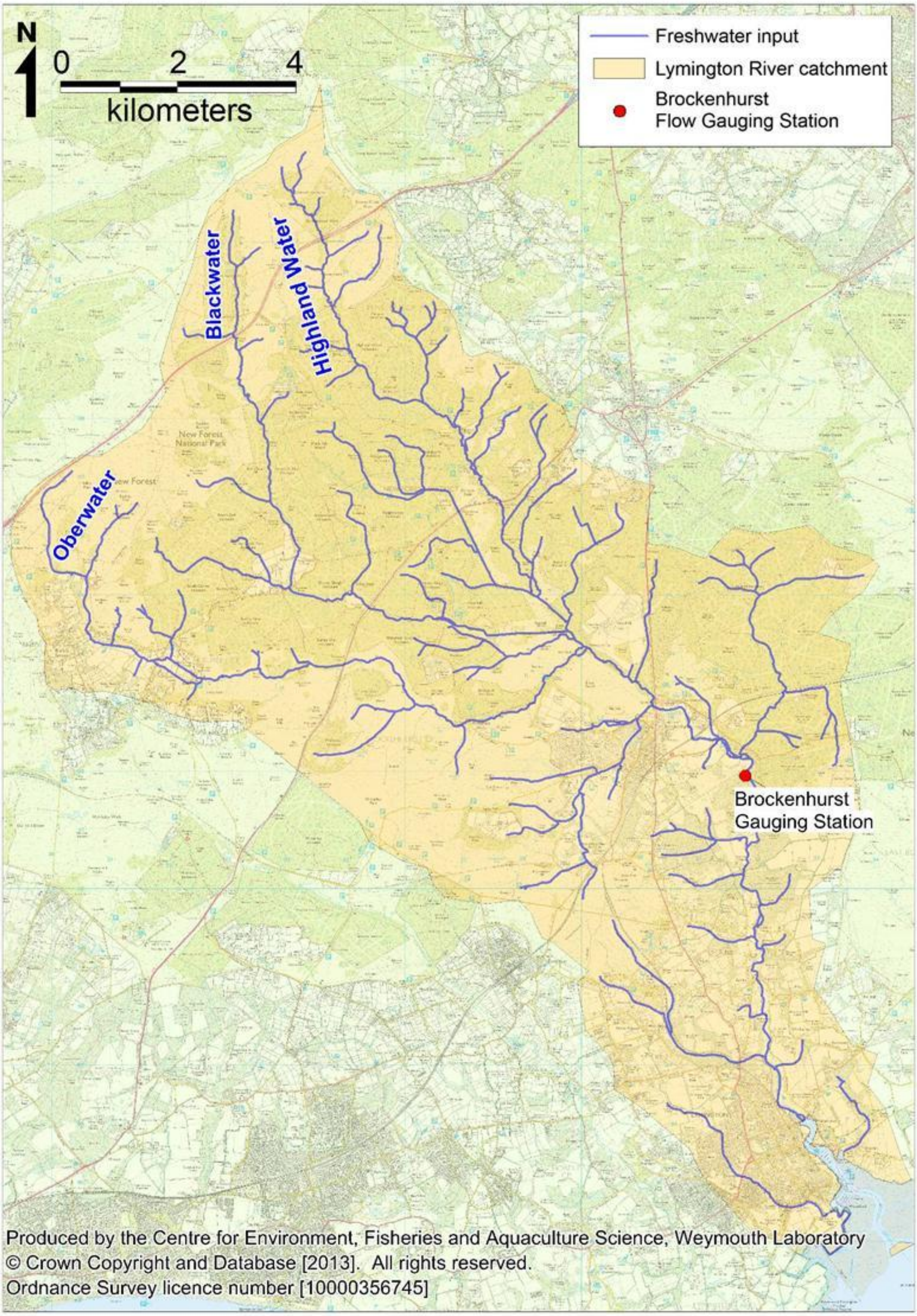


Figure 5.1: Watercourses within the Lymington catchment

The catchment is underlain by impermeable clays (West, 2007). Consequently the river flow is likely to be dominated by run-off which will result in a quick response to rainfall and large fluctuations in river flow. Summary statistics for the Lymington River at Brockenhurst are presented in Table VIII.1 for the period January 2003 – May 2013.

Table VIII.1: Summary flow statistics for Brockenhurst flow gauge station, 2003-2013

Watercourse	Station	Catchment Area (Km²)	Mean annual rainfall 1961 - 90 (mm)	Mean flow (m^3s^{-1})	Q95[1] (m^3s^{-1})	Q10[2] (m^3s^{-1})
Lymington	Brockenhurst	98.9	854	1.18	0.06	2.64

Data from the Environment Agency

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

The mean flow for the Lymington River is relatively high for its catchment size at 1.18 m³/s. Boxplots of mean daily flow record by month at Brockenhurst gauging station is presented in Figure VIII.2.

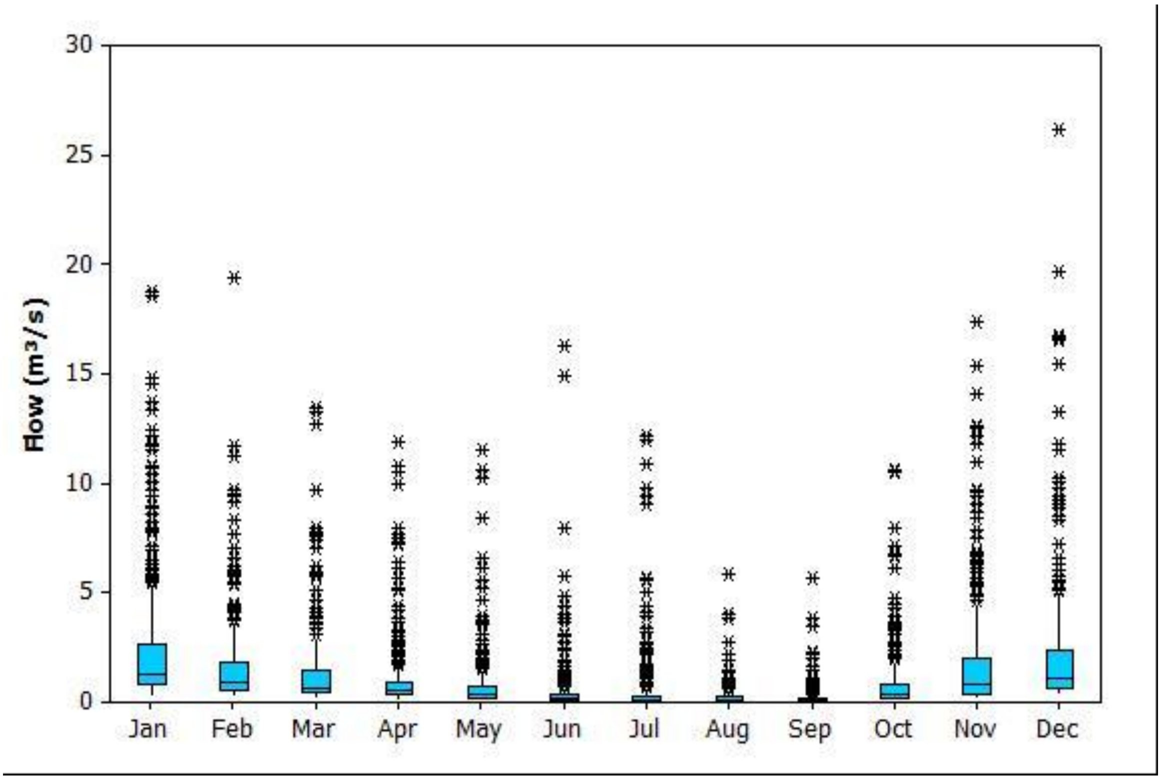


Figure VIII.2: Boxplots of mean daily flow records from the Brockenhurst gauging station on the Lymington river from 2003 – 2013.

Data from the Environment Agency

Flows were generally highest in the colder months. Flow rates however fluctuate quite considerably throughout on a day to day basis, with high flow events (>5 m^3/sec) recorded in all months of the year. A peak flow of just over 26 m^3/sec was recorded in the month of December. The seasonal pattern of flows is not entirely dependent on rainfall as during the colder months there is less evaporation and transpiration, and soils are more likely to be waterlogged. This in turn leads to a greater level of runoff relative to rainfall. In general, increased levels of runoff are likely to result in an increase in the amount of microorganisms carried into coastal waters although this may not always be the case.

Additionally, higher runoff will decrease residence time in rivers, allowing contamination from more distant sources to have an increased impact during high flow events.

During the shoreline survey, the unnamed watercourse discharging to the east shore by the ferry terminal was sampled and measured. There were two adjacent piped outfalls through which it discharges, and the combined bacterial loading they were carrying at the time was 2.3×10^{11} *E. coli* cfu/day. Their combined rate of discharge was only 0.11 m^3/sec, which is minor in relation to the Lymington River. The small watercourse discharging to the west bank of the lower estuary was not sampled or measured as it was considered too far away from the fishery to be of significance. It is therefore concluded that there is likely to be an overall gradient of decreasing levels of runoff borne contamination from the sluice gates down to the estuary mouth. The magnitude of this is likely to fluctuate significantly from day to day and season to season in response to rainfall and other factors.

Appendix IX. Hydrography

IX.1. Bathymetry

The Lymington estuary is a drowned river valley with one main deepwater channel running its length, which meanders along the north west- south east plane and discharges into the western Solent. The channel is only about 3km in length and extends as far as a sluice gate at its tidal limit. It is 2-4m in depth relative to chart datum throughout most of its length, decreasing to about 1m at the railway bridge.

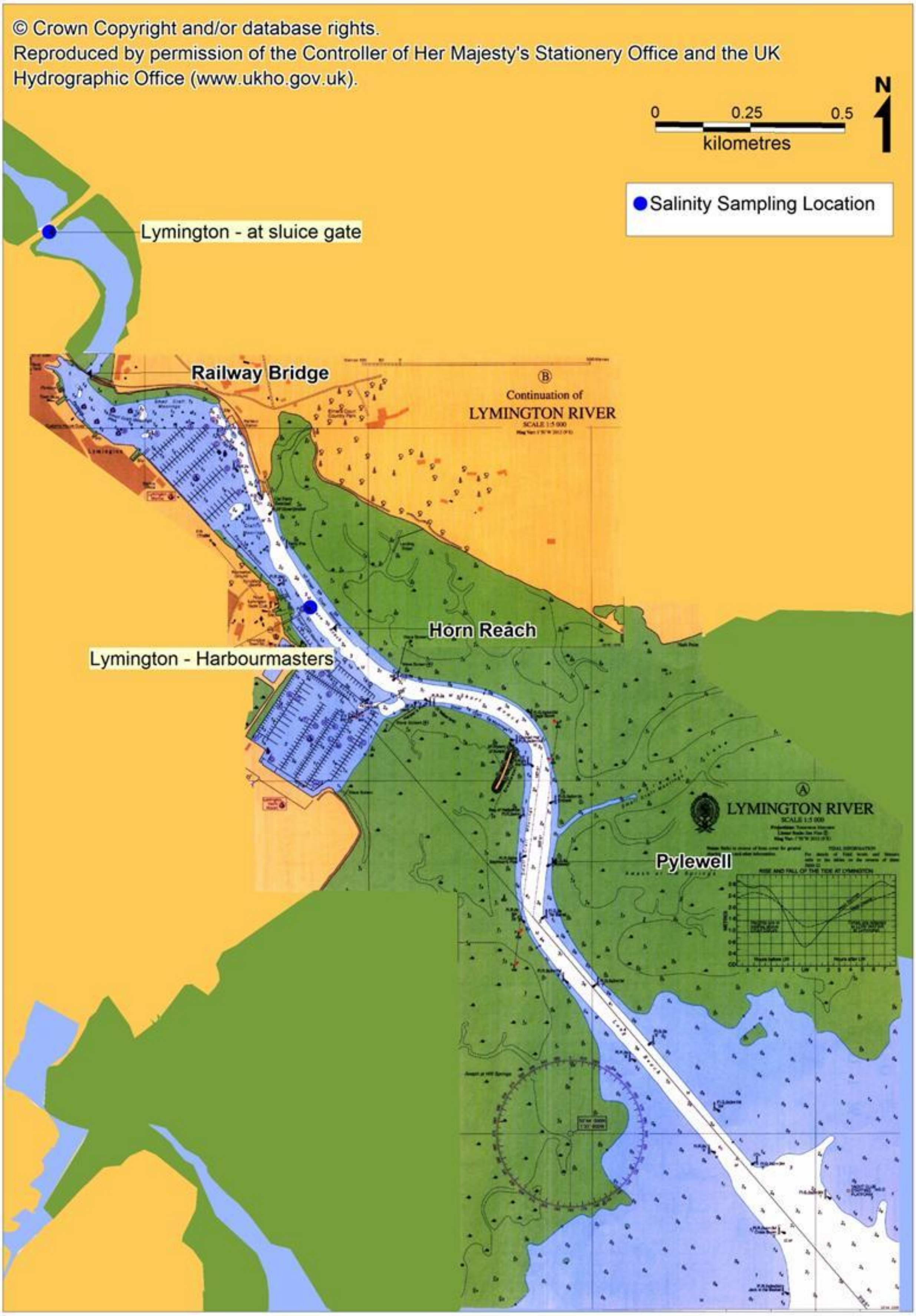


Figure IX.1: Bathymetry Chart of Lymington Estuary with salinity sampling sites
Admiralty Chart 5600.4

Overall, the estuary is short and wide, covering an area of about 2.4km² of which 80% is intertidal. The upper reaches in which the fishery is located consist of a relatively narrow and confined channel where the shoreline is heavily developed. The lower reaches widen greatly, where the relatively narrow navigation channel (<200m width) is flanked by large expanses of saltmarsh drained by branching creeks feeding back into the main channel. Dredging occurs in the main navigational channel and around the moorings and berths each winter (ABPmer, 2012). The bathymetry and shape of the estuary suggests that the potential for dilution and flushing of contamination is much more limited in the upper reaches.

Tides and Currents

Currents in coastal waters are predominantly driven by a combination of tide, wind and freshwater inputs. The Lymington estuary is meso-tidal and expresses a semi diurnal cycle with an average tidal range on spring tides of 2.4m. Double high waters occur at or near springs; on other occasions there is a stand which lasts about 2 hours within the Lymington estuary. Tides are asymmetrical, with a shorter duration and faster moving ebb tide (ebb dominant).

Table IX.1: Tide levels and ranges within the Lymington Estuary

	Height above chart datum (m)				Range (m)	
Port	**MHWS**	**MHWN**	**MLWN**	**MLWS**	**Spring**	**Neap**
Lymington	3.1	2.6	1.5	0.7	2.4	1.1

Data from Admiralty TotalTide

In the Solent tidal streams flood parallel to the coast in an easterly direction, and the reverse occurs on the ebb. The estuary therefore fills with water moving along the Solent shore from the west, so any major sources discharging to this stretch of coast may add to levels of contamination within it. The general pattern of tidal circulation within the estuary is bi-directional, with water moving up the estuary on the flood and back out on the ebb, with the main flow aligning with the main channel. As the main channel fills the tidal streams move up intertidal channels and spread over the extensive intertidal saltmarsh/mudflats. The reverse occurs on an ebb tide. There are no tidal diamonds within the Lymington Estuary and very limited firm information on tidal streams. Some ADCP measurements were undertaken at intervals across a spring tidal cycle at Pylewell, in the outer channel, and at Horn Reach, just upstream of the Lymington Yacht Haven (BMT Seatech, 2008). As expected, currents at both stations aligned with the channel orientation. Current speeds were quite low, and higher at Pylewell than at Horn Reach, with peak ebb currents of 0.57 and 0.20m/s respectively. Very approximate estimates of tidal excursion based on these measurements are in the order of 5 and 2km on spring tides. Current velocities will be considerably lower on neap tides, typically around half that observed on spring tides.

Advection of pollutants by tidal currents is likely to be the main mode of contaminant transport in the Lymington. The flood tide will convey relatively clean water originating from the Solent into the estuary, whereas the ebb tide will carry contamination from shoreline sources out through the estuary. Shoreline sources of contamination discharging to the upper estuary will primarily impact up and downstream of their locations along the bank to which they discharge. The relatively low current speeds, particularly within the inner reaches of the estuary where the shellfishery is located will mean contamination from more distant sources (>2km distant) will not generally reach the fishery during the course of a tide. Contamination from sources discharging to the saltmarsh creeks of the outer estuary will not impact directly on the shellfishery in the upper reaches, as it will tend to remain confined in the creeks during the flood, and will then be carried out of the estuary on the ebb tide.

In addition to tidally driven currents, are the effects of freshwater inputs and wind. The vast majority of freshwater input to the estuary is via the Lymington River, which discharges at its head. The flow ratio (freshwater input:tidal exchange) is very low and the system is well mixed. However, the maximum flow ratio, suggests occasional stratification may occur on an ebb tide at high river flows (Futurecoast, 2002). Therefore, density driven circulation is unlikely to modify tidal circulation within the estuary as a whole except at times of high river flows. Repeated salinity measurements were taken by the Environment Agency at two points within the Lymington estuary, (Figure IX.1) upstream and downstream of the fishery.

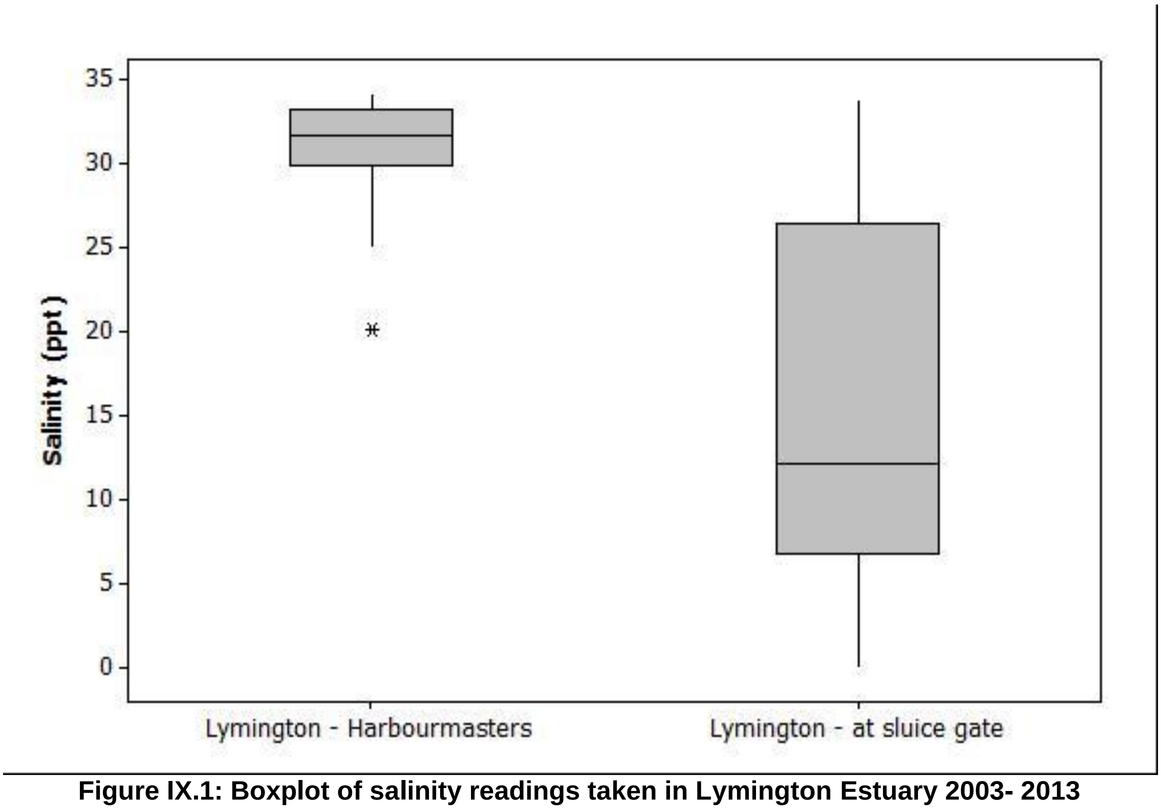


Figure IX.1: Boxplot of salinity readings taken in Lymington Estuary 2003- 2013
Data from the Environment Agency

The sluice gate site lies at the tidal limit, and salinity here varied from pure freshwater to almost full strength seawater (0.08-33.8 ppt). This suggests there may be some density effects at times in the very upper reaches. If such effects occur, they may result in a shear between surface and bottom currents, with less dense freshwater moving in a net seaward direction at the surface, and a net movement of more saline water up-estuary lower in the water column. Tidal state and river discharge will drive the major salinity fluctuations observed here, and throughout the rest of the estuary to a decreasing extent. At the Harbourmaster site salinities were generally approaching that of full strength seawater, but on some occasions they were less than 30 ppt, and the minimum recorded was 20 ppt. Salinity is an indicator of the degree of freshwater influence, and hence the amount of runoff borne contamination. In the Lymington estuary decreased salinity was correlated with increased concentrations of bacterial indicators (Appendix X). The oyster site is approximately at the midpoint between these two sites, so significant fluctuations in salinity (and runoff borne contamination) may be expected at times, but not to the extent observed at the sluice gate.

The sluice gates at the Lymington Bridge close when tidal levels are higher than the water levels in the river (Solomon, 2010). Therefore, around high water there will be a period during which the river does not discharge. In combination with the increased dilution available at high water, it is likely that the pattern of discharge will result in markedly lower salinities arising around low water in the very upper reaches of the estuary.

Strong winds will modify surface currents. Winds typically drive surface water at about 3% of the wind speed (Brown, 1991) so gale force wind (34 knots or 17.2 m/s) would drive surface water currents which may travel lower in the water column or along sheltered margins. The prevailing south westerly winds will tend to push surface water in a north easterly direction. Exact effects are dependent on the wind speed and direction as well as state of the tide and other environmental variables so a great number of scenarios may arise. Where strong winds blow across a sufficient distance of water they may create wave action, and where these waves break contamination held in intertidal sediments may be resuspended. Given the enclosed nature of the Lymington estuary strong wave action is not anticipated, although sediments are fine and easily disturbed. The washes created by boat traffic may also regularly disturb sediments.

Appendix X. Microbiological Data: Seawater

X.1. Summary statistics and geographical variation

There are no shellfish waters sites designated under Directive 2006/113/EC (European Communities, 2006) in the Lymington estuary; however, water samples have been taken by the Environment Agency from two sites to monitor water quality of the estuary. Figure X.1 shows the location of these monitoring points. Table X.1 presents summary statistics for bacteriological monitoring results and Figure X.2 present boxplots of faecal coliform levels from the monitoring points.

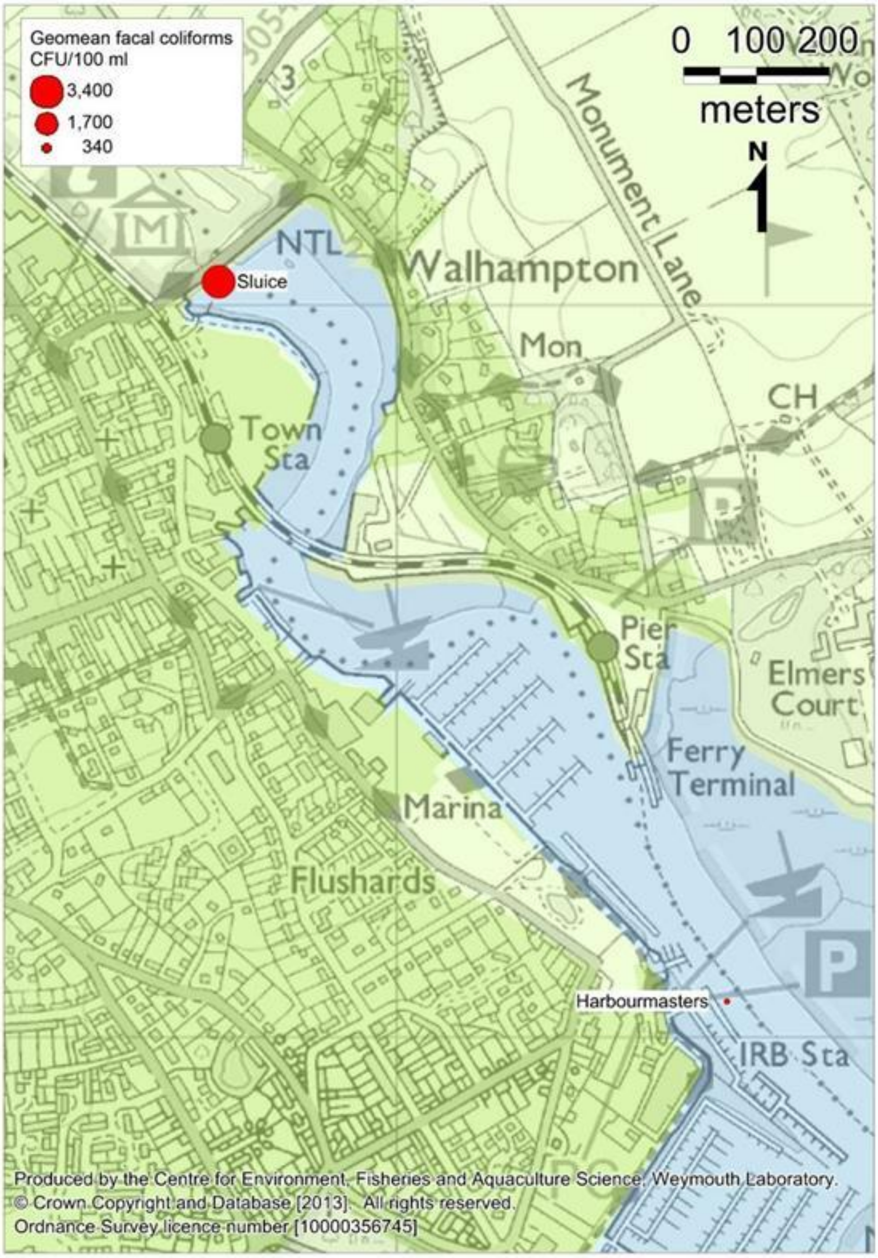


Figure X.1: Location of monitoring points in the Lymington Estuary

Table X.1: Summary statistics for bathing waters faecal coliform results, 2010 to 2012 (cfu/100ml).

Site	No.	Date of first sample	Date of last sample	Geometric mean	Min.	Max.	% over 100	% over 1000	% over 10000
Sluice	17	29/11/2010	15/03/2012	3374.3	510	23000	100.0	88.2	17.6
Harbourmasters	17	29/11/2010	15/03/2012	153.1	5	4100	58.8	17.6	0.0

Data from the Environment Agency

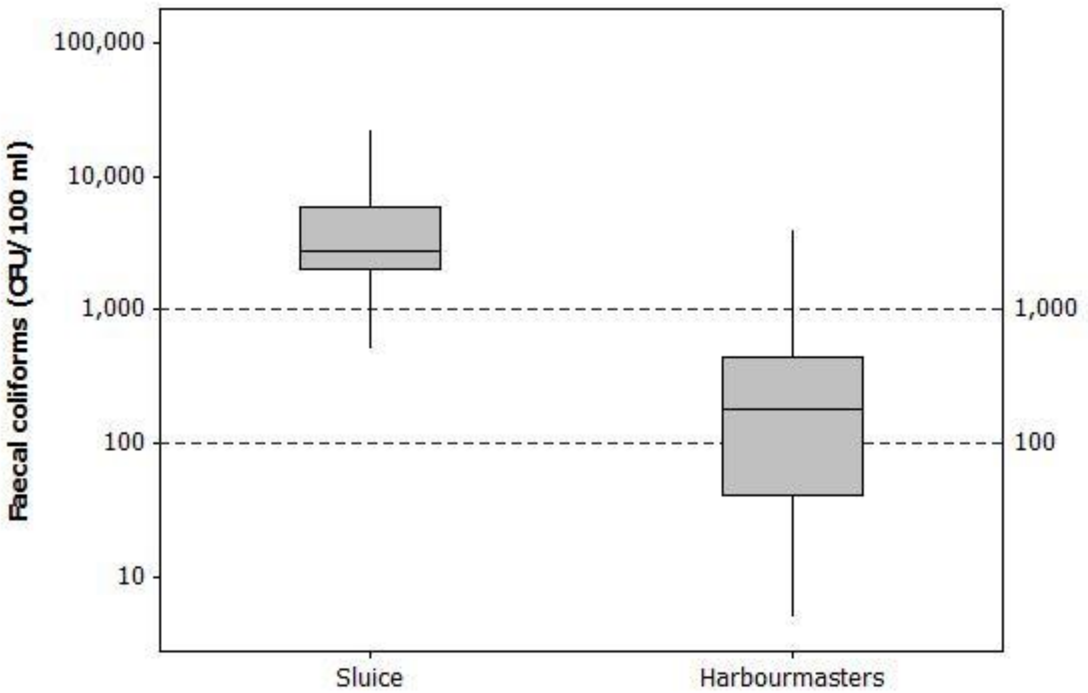


Figure X.2: Box-and-whisker plots of all faecal coliforms results by site
Data from the Environment Agency

Both sites had results exceeding 1,000 faecal coliforms/100 ml but only Sluice had any results exceeding 10,000 faecal coliforms/100 ml. Levels of contamination at Sluice were very high. Sluice had significantly higher faecal coliforms levels than Harbourmasters (paired t-test, p=0.000). Although only two points were sampled, the results suggest a gradient of increasing contamination towards the upper reaches of the estuary.

X.2. Overall temporal pattern in results

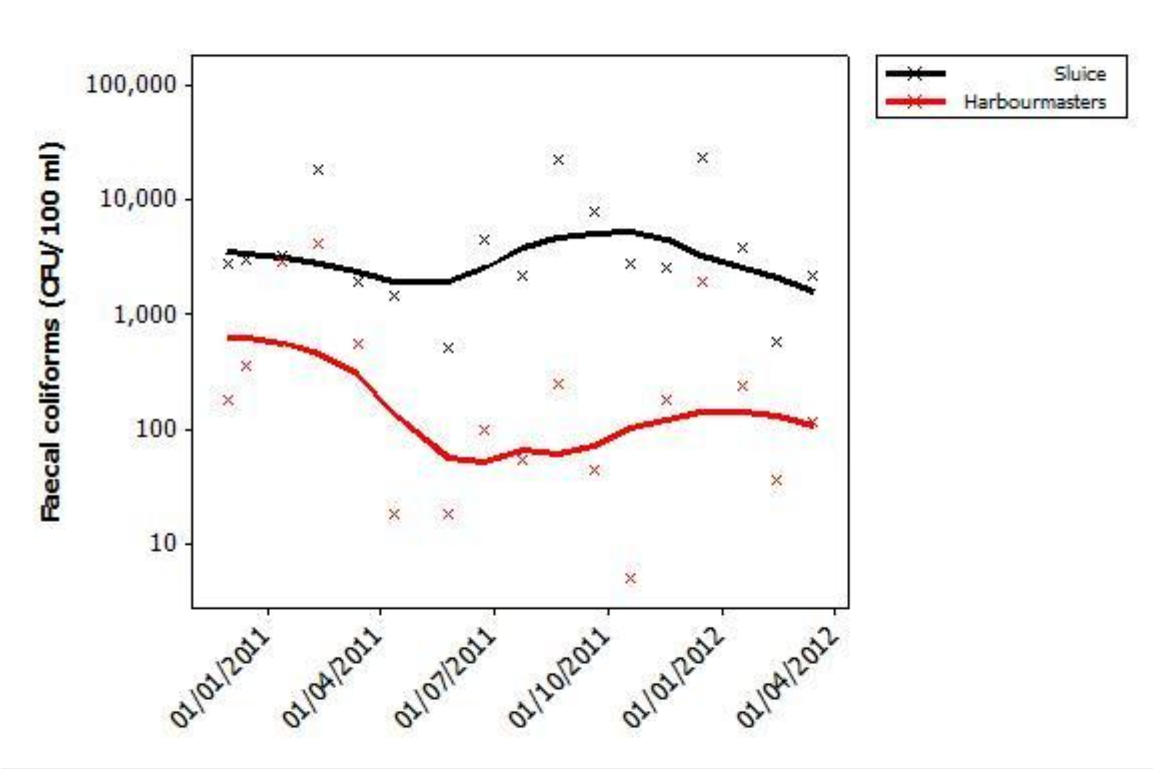


Figure X.3: Scatterplot of faecal coliform results by site and date, overlaid with loess lines
Data from the Environment Agency

Figure X.3 suggests that faecal coliform levels decreased at Harbourmasters in 2011, and remained lower. However, levels have remained fairly constant at Sluice.

X.3. Seasonal patterns of results

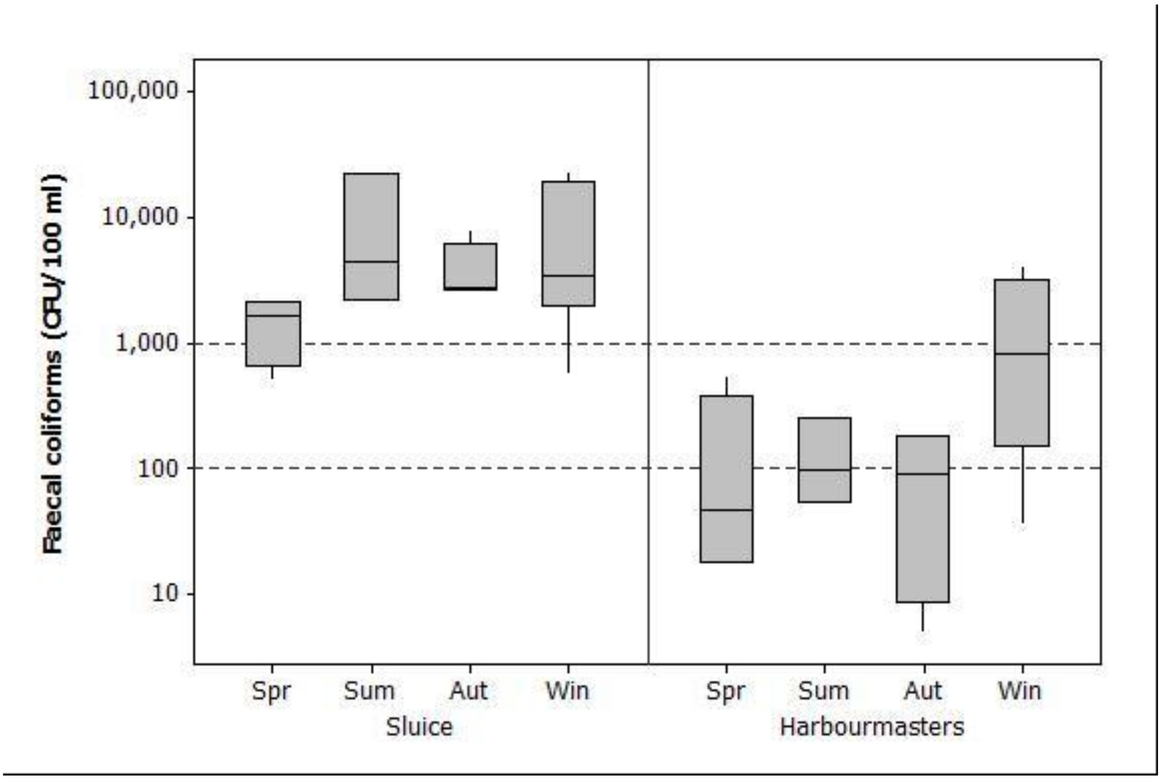


Figure X.4: Boxplot of faecal coliform results by site and season
Data from the Environment Agency

Comparisons (One-way ANOVA) of faecal coliform levels at both sites between seasons revealed that there were no significant differences between seasons (p = 0.252 and 0.105 at Sluice and Harbourmasters respectively) (Figure X.4). Sample numbers were probably too low for a meaningful statistical analysis however. A tendency for higher results in the winter can be seen at Harbourmasters, and a tendency for lower results in the spring is apparent at Sluice.

X.4. Influence of rainfall

To investigate the effects of rainfall on levels of contamination at the water quality monitoring sites Spearman's rank correlations were carried out between rainfall recorded at the Brockenhurst weather station (Appendix II for details) over various periods running up to sample collection and faecal coliform results. These are presented in Table X.2 and statistically significant correlations (p<0.05) are highlighted in yellow.

Table X.2: Spearmans Rank correlation coefficients for faecal coliform results against recent rainfall

Site		Sluice	Harbourmasters
n		17	17
24 hour periods prior to sampling	1 day	0.570	0.519
	2 days	0.687	0.361
	3 days	0.351	0.661
	4 days	0.199	-0.017
	5 days	0.808	0.370
	6 days	0.226	-0.162
	7 days	0.439	0.543
Total prior to sampling over	2 days	0.818	0.419
	3 days	0.719	0.572
	4 days	0.689	0.464
	5 days	0.751	0.513
	6 days	0.629	0.363
	7 days	0.613	0.351

Data from the Environment Agency

Some influence of rainfall was detected at both sites. Unsurprisingly, this was stronger at the upstream site (Sluice).

X.5. Influence of salinity

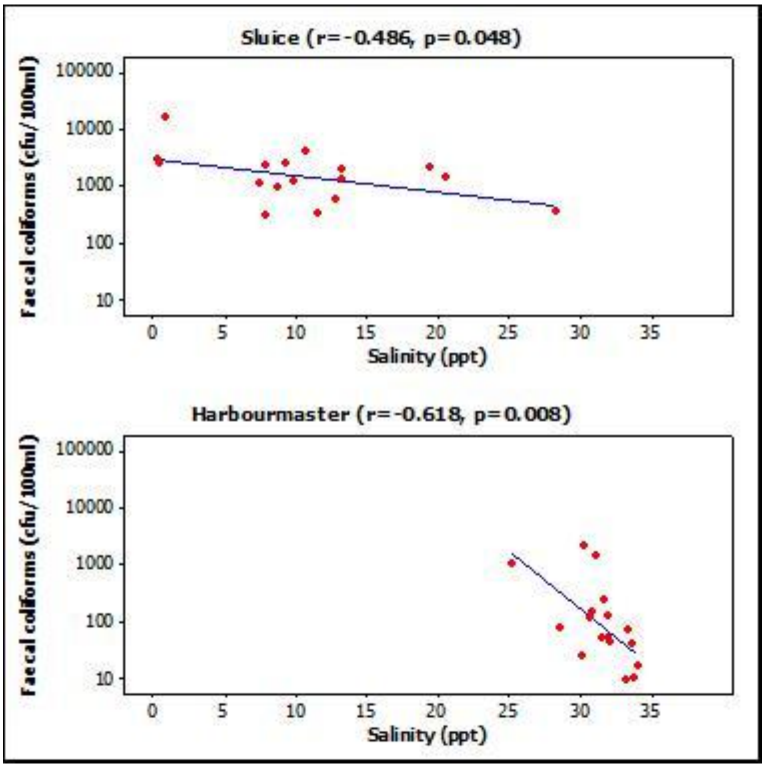


Figure X.5: Scatterplot of faecal coliforms against salinity
Data from the Environment Agency

Significant negative correlations were found between salinity and faecal coliforms at both sites (Figure X.5). The correlation was stronger at Harbourmaster, where faecal coliform results were much lower, and there was less freshwater influence.

Appendix XI. Microbiological Data: Shellfish Flesh

XI.1. Summary statistics and geographical variation

The location of the RMP in the Lymington estuary is presented in Figure XI.1. It was established before the holding area was moved to Town Slipway and now lies on the opposite bank to the location currently used. Summary statistics are presented in Table XI.1 and a boxplot showing the distribution of *E. coli* levels at the RMP is presented in Figure XI.2.

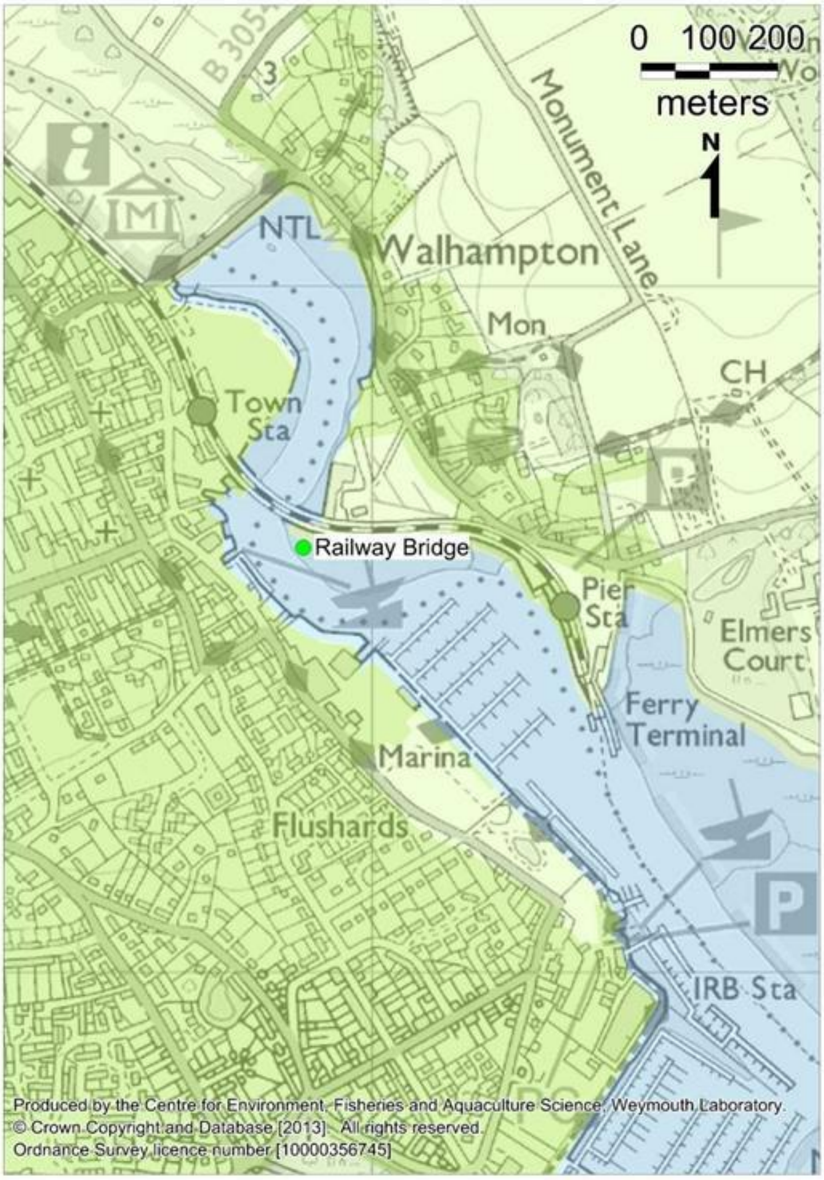


Figure XI.1: RMPs in Lymington Estuary

Table XI.1: Summary statistics of *E. coli* results (MPN/100g) from the native oyster RMP sampled from 2003 onwards

RMP	Railway Bridge
Species	Native oyster
No.	108
Date of first sample	28/01/2003
Date of last sample	26/03/2013
Geometric mean	1766.7
Min.	40
Max.	54000
% over 230	92.6
% over 4600	25.0
% over 46000	2.8

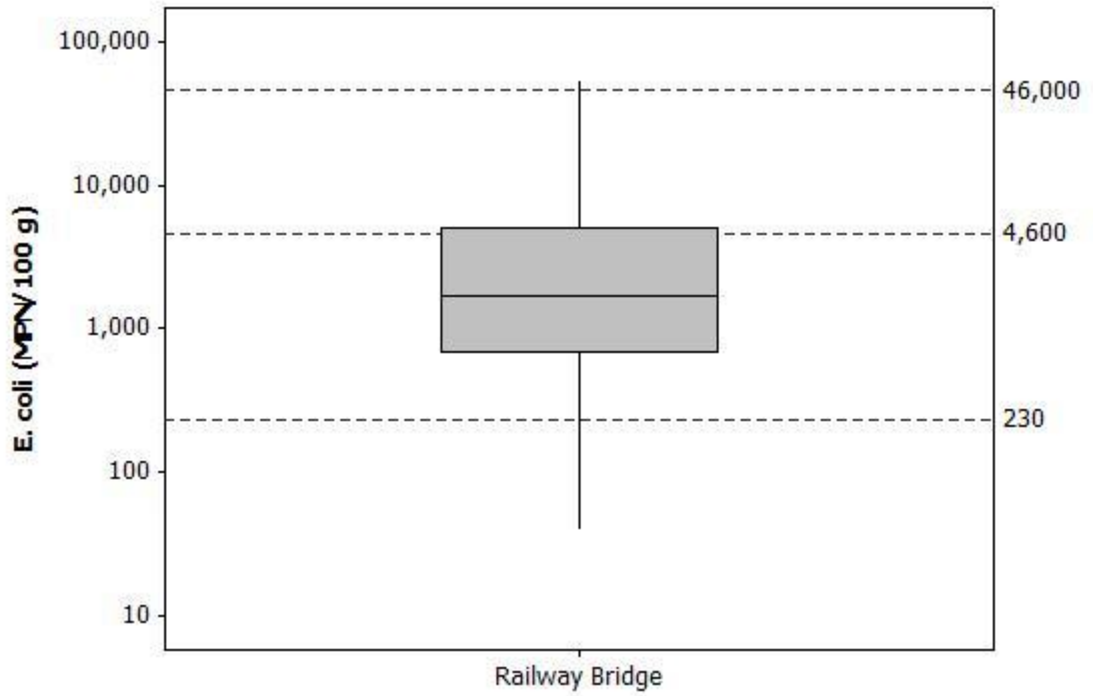


Figure XI.2: Boxplot of *E. coli* results from the RMP sampled from 2003 onwards

Results here are variable, ranging from 40 to 54,000 *E. coli* MPN/100g. Over 25% of results here exceeded 4600 *E. coli* MPN/100g, and occasional prohibited level results have been recorded. This indicates high levels of contamination at this RMP.

XI.2. Overall temporal pattern in results

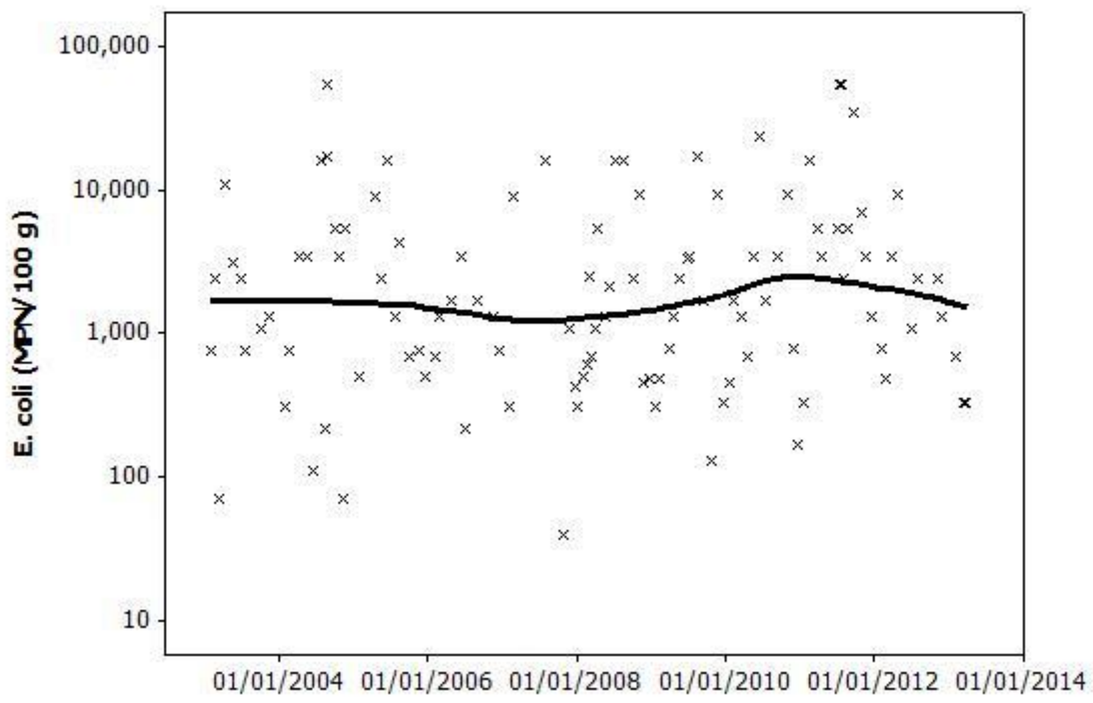


Figure XI.3: Scatterplot of *E. coli* results by date, overlaid with a loess line

Figure XI.3 shows some slight fluctuations over the years, but in general *E. coli* levels have remained stable year to year.

XI.3. Seasonal patterns of results

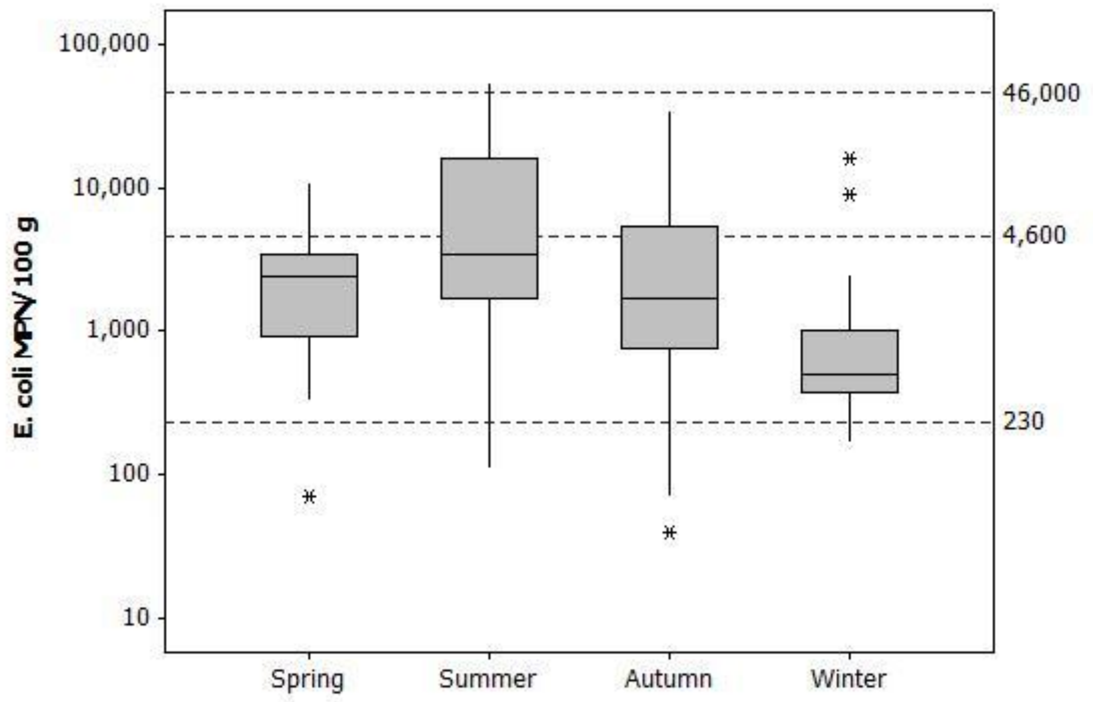


Figure XI.4: Boxplot of *E. coli* results by RMP and season

A one-way ANOVA comparing *E. coli* levels between seasons revealed that there was a significant difference in contamination between seasons ($p < 0.001$) (Figure XI.4). A post ANOVA Tukey test showed that there were higher levels of *E. coli* in summer than in winter.

XI.4. Influence of tide

To investigate the effects of tidal state on *E. coli* results, circular-linear correlations were carried out against the high/low and spring/neap tidal cycles. The results of these correlations are summarised in Table XI.2, with significant results highlighted in yellow.

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

High/low tides		Spring/neap tides	
r	p	r	p
0.133	0.155	0.175	0.040

Figure XI.5 presents polar plots of $\log_{10}$ *E. coli* results against the spring/neap tidal cycle for those RMPs that showed a significant correlation. Full/new moons occur at 0º, and half moons occur at 180º, and the largest (spring) tides occur about 2 days after the full/new moon, or at about 45º, then decrease to the smallest (neap tides) at about 225º, then increase back to spring tides. Results of 230 *E. coli* MPN/100g less are plotted in green, those from 231 to 4,600 are plotted in yellow, and those exceeding 4,600 are plotted in red.

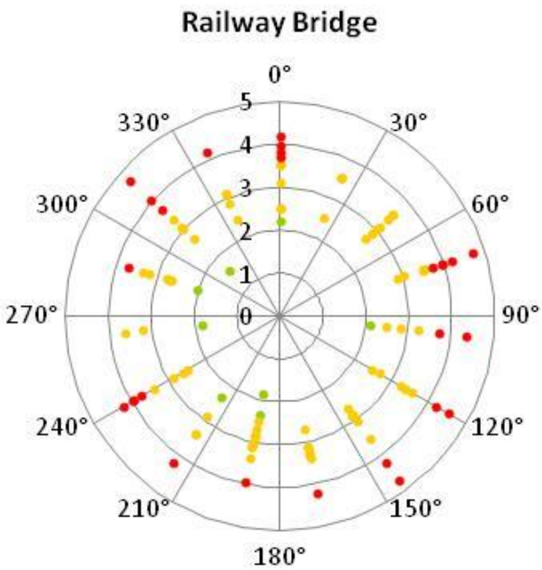


Figure XI.5: Polar plot of $\log_{10}$ *E. coli* results (MPN/100g) against tidal state on the spring/neap tidal cycle

The correlation was weak, and no strong patterns are apparent in Figure XI.5.

XI.5. Influence of rainfall

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

Site		**Railway Bridge**
Species		**Native oyster**
n		**105**
24 hour periods prior to sampling	1 day	0.061
	2 days	0.029
	3 days	0.164
	4 days	0.178
	5 days	0.113
	6 days	0.036
	7 days	0.166
Total prior to sampling over	2 days	0.098
	3 days	0.129
	4 days	0.163
	5 days	0.188
	6 days	0.181
	7 days	0.179

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

Levels of *E. coli* appear to be influenced to some extent by the level of rainfall 3-4 days after a rainfall event.

Appendix XII. Shoreline Survey Report

Date (time): 18/06/2013 (09:00 – 12:00)

Cefas Officer: David Walker

Local Enforcement Authority Officer: Dale Bruce (New Forest District Council)

Area surveyed: Perimeter of Lymington River Estuary (Figure XII.1)

Weather: Dry, overcast, 17°C, Wind bearing 150°, Wind speed 3.2 km/h

Tides:

Admiralty TotalTide tidal predictions for Lymington (50°46'N 1°32'W). All times in this report are BST.

18/06/2013

	Time	Height
High	05:22	2.6 m
	19:42	2.8 m
Low	11:00	1.2 m
	23:36	1.3 m

XII.1. Objectives

The shoreline survey aims to obtain samples of freshwater inputs to the area for bacteriological testing; confirm the location of previously identified sources of potential contamination; locate other potential sources of contamination that were previously unknown and find out more information about the fishery. A full list of recorded observations is presented in Table XII.1 and the locations of these observations are mapped in Figure XII.1. Photographs are presented in Figure XII.3 to Figure XII.12. Every effort was made to ensure the entire shoreline was surveyed, however a construction site to the south of the road bridge and north of the railway bridge prevented access to one short section.

XII.2. Description of Fishery

The Lymington River native oyster fishery is located next to the town slipway in Lymington (observation 4, Figure XII.1). It is used only as temporary storage of oysters that have been taken from the Solent area. Oysters are left in the fishery until enough have been harvested to make transporting them commercially viable. The length of time that the oysters are left in the fishery is typically one to two days, and harvesting takes place approximately once or twice a year.

XII.3. Sources of contamination

Sewage discharges

There are five CSOs registered on the EA discharge database which discharge into the Lymington River estuary. The location of only one of these was confirmed by this survey (observation 5). The other four could not be seen. One is located at the end of the town slipway, which is immediately adjacent to the shellfishery. If a spillage event was to coincide with when the oysters are stored at this site, this poses a significant potential health risk. The current RMP is located on the opposite bank from the harvesting site and is therefore unlikely to detect the effects of any spillage events on the levels of faecal contamination in oysters.

In addition to CSOs, there are several private discharges located around the estuary. The locations of only three of these were confirmed by this survey (observations 7, 8 and 9). Observation 7, contained 280 *E. coli* CFU/100 ml, but had a relatively low flow rate.

Freshwater inputs

It was not possible to sample the Lymington River itself due to limitations of access. A pipe which extends from the harbour wall at observation 2 is connected to the pumps at observation 3. According to Pump Services, who maintain the pump, this is a storm water pumping station. Observations 10 and 11 were sluices for a small water course which drains water from a series of ponds to the south of Portmore. There is also a private discharge from Walhampton School on this water course downstream of the ponds which may help to explain the relatively high levels of *E. coli* which were found here (samples L03 and L04).

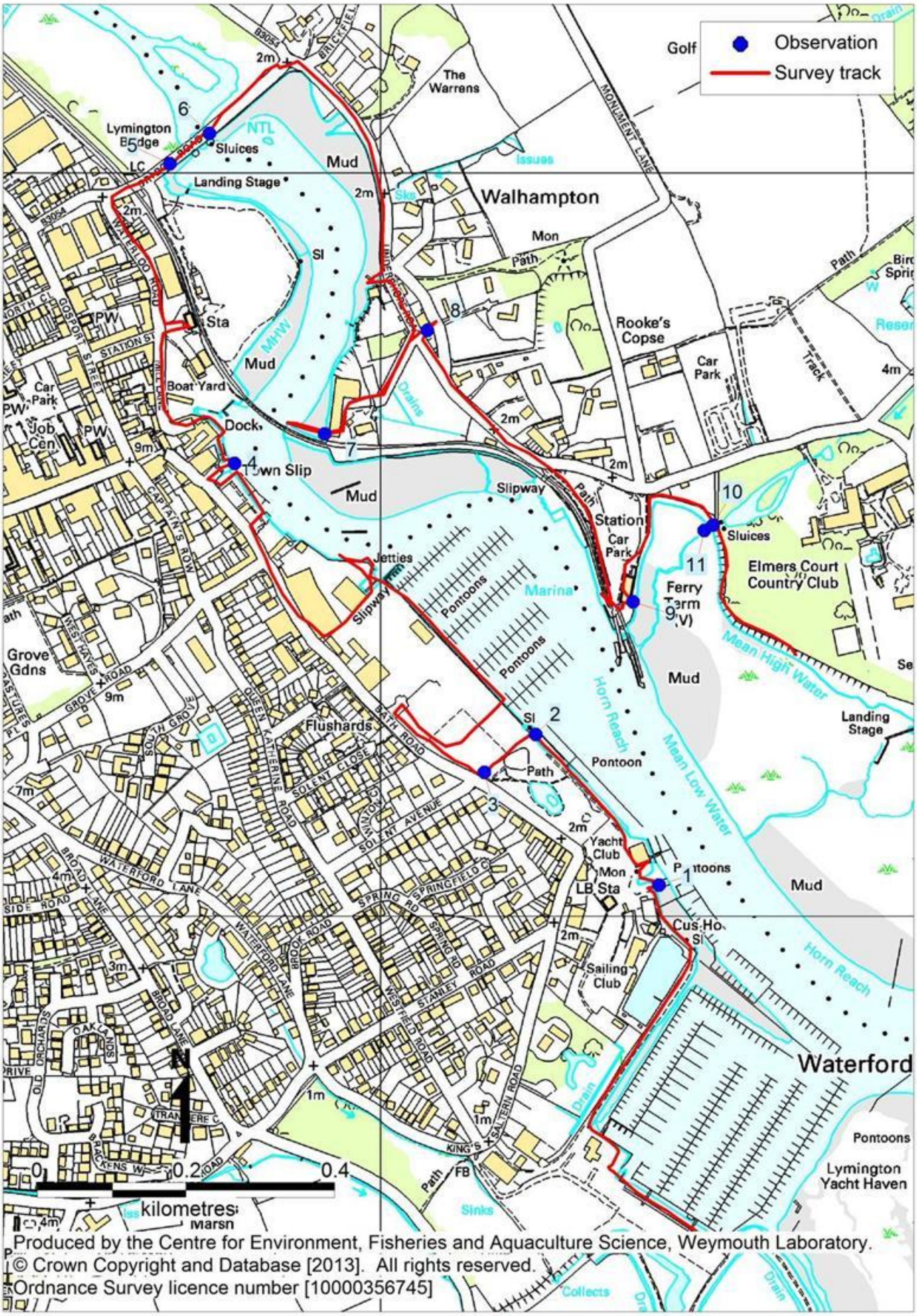
Boats and shipping

Lymington has a small but busy ferry terminal which takes cars to and from the Isle of Wight. Lymington is also very popular for recreational boating and as well as two marinas there are several pontoons for berthing small craft.

A water sample was taken just north of Lymington Yacht Haven marina and was found to contain 1,300 *E. coli*/100 ml, suggesting there may be a source of contamination nearby, possibly from the boats in the marina.

Building developments

A new residential development called Lymington Shores was under construction at the time of the survey. This will have 168 dwellings and may also have a pontoon extending into the river. During the survey, what appeared to be a concrete drain from the site was observed (Observation 5, Figure XII.7).



Produced by the Centre for Environment, Fisheries and Aquaculture Science, Weymouth Laboratory.
© Crown Copyright and Database [2013]. All rights reserved.
Ordnance Survey licence number [10000356745]

Figure XII.1: Locations of shoreline observations (see Table XII.1 for details)

Table XII.1: Details of shoreline observations

Observation no.	NGR	Time	Description	Photo
1	SZ 33374 95042	09:33	RNLI slipway - Adjacent to north of marina	Figure XII.3
2	SZ 33208 95245	09:40	Iron pipe 20 cm diameter - not flowing (possible sluice)	Figure XII.4
3	SZ 33139 95194	09:42	Inspection covers and pumping station possibly for observation 2.	Figure XII.5
4	SZ 32803 95609	10:02	Oyster storage area (no markings and no oysters present)	Figure XII.6
5	SZ 32716 96012	10:11	CSO. Also pipe visible on other side of water & a new looking drain from building site	Figure XII.7
6	SZ 32769 96053	10:16	Lymington river sluice	
7	SZ 32924 95649	10:33	Private discharge (valve). Flow measured as 200ml in 3 seconds	Figure XII.8
8	SZ 33062 95788	10:46	Septic tank	Figure XII.9
9	SZ 33339 95423	10:54	Enclosure and drain cover	Figure XII.10
10	SZ 33447 95526	11:16	Pipe outlet (40 cm pipe)	Figure XII.11
11	SZ 33435 95519	11:21	Pipe outlet (15cm pipe)	Figure XII.12

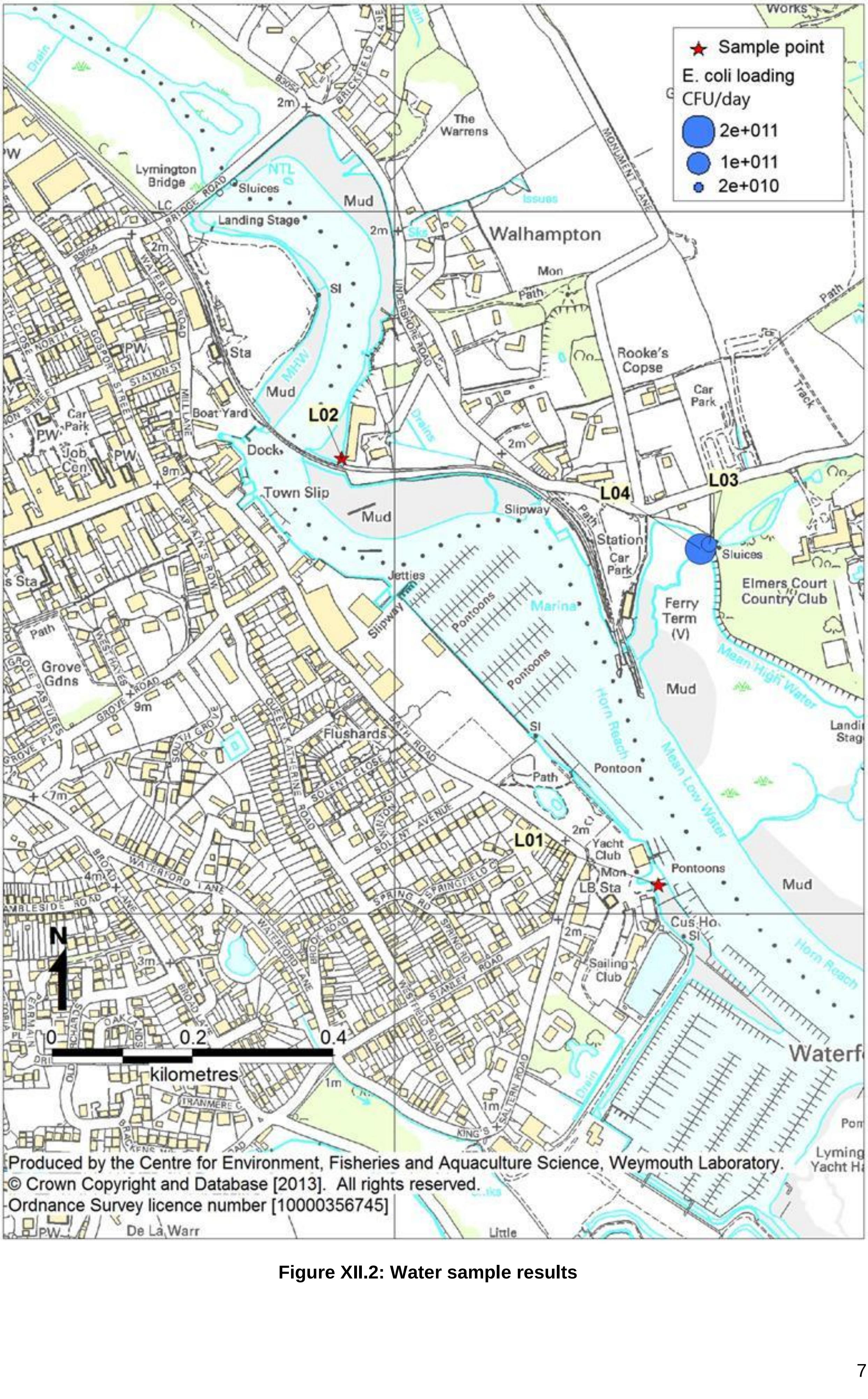


Figure XII.2: Water sample results

Table 5.2: Water sample *E. coli* results, spot flow gauging results and estimated stream loadings

Observation no.	Flow (m^3/s)	Sample ID	*E. coli* concentration (CFU/100 ml)	*E. coli* loading (CFU/day)
1		L01	1,300	
7	$6.7x10^{-5}$	L02	280	$1.61x10^{7}$
10	0.08	L03	800	$5.24x10^{10}$
11	0.03	L04	7,400	$1.80x10^{11}$

Figure XII.3

Figure XII.4

Figure XII.5

Figure XII.6

Figure XII.7

Figure XII.8

Figure XII.9

Figure XII.10

Figure XII.11

Figure XII.12

References

ABPmer, 2012. Wightlink – Replacement Lymington to Yarmouth ferries. Monitoring possible effects of the W-class ferries. Progress report 20 and 2nd report for the environmental management panel. Report R.1556t. December 2012.

Ashbolt, J. N., Grabow, O. K., Snozzi, M., 2001. Indicators of microbial water quality. In Fewtrell, L. and Bartram, J. (Eds). Water quality: guidelines, standards and health. IWA Publishing, London. pp. 289−315.

BMT Seatech, 2008. Ferry Operations at Lymington, Phase 1: The Present Situation and Future Predictions. Report No. C13537.R01.V2. March 2008.

Brown J., 1991. The final voyage of the Rapaiti. A measure of surface drift velocity in relation to the surface wind. Marine Pollution Bulletin 22: 37-40.

Council of the European Communities, 1975. Council Directive 76/160/EEC of 8 December 1975 concerning the quality of bathing water. Official Journal L031: 0001-0007.

EU Working Group on the Microbiological Monitoring of Bivalve Harvest Areas (2010). Microbiological Monitoring of Bivalve Harvest Areas. Guide to Good Practice: Technical Application. Issue 4, August 2010.

European Communities, 2004. EC Regulation No 854/2004 of the European Parliment and of the Council of 29 April 2004 laying down specific hygiene rules on products of animal origin intended for human consumption. Official Journal of the European Communities L226: 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 Communities L376: 14-20.

Futurecoast, 2002. Department of Environment, Food and Rural Affairs (Defra), Halcrow Group Ltd 3 CD set.

Geldreich, E.E., 1978. Bacterial and indicator concepts in feces, sewage, stormwater and solid wastes. In Berg, G. (ed.). Indicators of Viruses in Water and Food. MI: Ann Arbor.

Hampshire & Isle of Wight Wildlife Trust, 2011. Tracking the Solent's Seals. Available at: http://pmnhs.co.uk/wp-content/uploads/2011/11/jolyonchesworth.pdf Accessed: June 2013

Hampshire County Council, 2011. Hampshire Factsheets 15: Tourism. Available at: http://www.hants.gov.uk/rh/tourism-section/tourism-facts.pdf . Accessed on: January 2013

Hampshire County Council, 2013. Lymington-Keyhaven Nature Reserve. http://www3.hants.gov.uk/hampshire-countryside/lymington-keyhaven.htm

Holt, C., Austin, G., Calbrade, N., Mellan, H., Mitchell, C., Stroud, D., Wotton, S., Musgrove, A., 2011. Waterbirds in the UK 2009/10. The Wetland Bird Survey.

Holt, C., Austin, G., Calbrade, N., Mellan, H., Hearn, R., Stroud, D., Wotton, S., Musgrove, A., 2012. Waterbirds in the UK 2010/11. The Wetland Bird Survey.

Hughes, C., Gillespie, I.A., O'Brien, S.J., 2007. Foodborne transmission of infectious intestinal disease in England and Wales 1992-2003. Food Control 18: 766−772.

Kay, D, Crowther, J., Stapleton, C.M., Wyler, M.D., Fewtrell, L., Anthony, S.G., Bradford, M., Edwards, A., Francis, C.A., Hopkins, M. Kay, C., McDonald, A.T., Watkins, J., Wilkinson, J., 2008a. Faecal indicator organism concentrations and catchment export coefficients in the UK. Water Research 42, 442-454.

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

Lee, R.J., Younger, A.D., 2002. Developing microbiological risk assessment for shellfish purification. International Biodeterioration and Biodegradation 50: 177−183.

Lymington Harbour Authority, 2013. Website page on moorings. Available at: http://www.lymingtonharbour.co.uk/moorings/moorings.htm. Accessed June 2013.

Met Office, 2012. Regional Climates. Available at: http://www.metoffice.gov.uk/climate/regional/ Accessed October 2012.

Mitchell, P. Ian, S. F. Newton, N. Ratcliffe & T. E. Dunn, 2004. Seabird Populations of Britain and Ireland, Results of the Seabird 2000 Census (1998-2002). T&AD Poyser, London.

New Forest District Council, 2013. Tourism and Travel Print page. Available at: http://www.newforest.gov.uk/index.cfm?articleid=5197. Accessed on: April 2013

Obiri-Danso, K., Jones, K., 2000. Intertidal sediments as reservoirs for hippurate negative campylobacters, salmonellae, and faecal indicators in three EU recognised bathing waters in North-West England. Water Research 34(2): 519−527.

Palmer, D., Firmin, C., 2011. Solent Regulated Fishery Oyster Stock Survey 5 - 8 July 2011. Technical report. Centre for Environment, Fisheries and Aquaculture Science, Lowestoft Laboratory. 19 p.

Ports and Harbours of the UK, 2013. Lymington. Available at: http://www.ports.org.uk/port.asp?id=129 Accessed June 2013

Reeds Nautical Almanac, 2012. (Eds. Du Port, A. and Butress, R.) Aldard Coles Nautical, MS Publications, Colchester.

RSPB, 2013. Lymington – Keyhaven Nature Reserve. Available at: http://www.rspb.org.uk/ourwork/policy/marine/salinelagoons/lymington.aspx Accessed: June 2013

Solomon, D. J., 2010. Eel passage at tidal structures and pumping stations. Environment Agency Thames Region.

The Wildlife Trusts' South East Marine Programme, 2010. Solent Seal Tagging Project Summary Report. Available at: http://www.conservancy.co.uk/assets/assets/seal_report_2010.pdf. Accessed: June 2013

West, I., 2007. Solent Estuaries – Introduction. Geology of the Wessex Coast of Southern England. Available at: http://www.southampton.ac.uk/~imw/jpg-Solent/7SL-Geology-Solent-Ian-West.jpg. Accessed May 2015.

Younger, A.D., Lee, R.J., Lees, D.N. 2003. Microbiological monitoring of bivalve mollusc harvesting areas in England and Wales: rationale and approach. In: Villalba, A., Reguera, B., Romalde, J. L., Beiras, R. (eds). Molluscan Shellfish Safety. Consellería de Pesca e Asuntos Marítimos de Xunta de Galicia and Intergovernmental Oceanographic Commission of UNESCO, Santiago de Compostela, Spain. pp. 265−277.

Younger, A.D., Reese, R.A.R., 2011. *E. coli* accumulation compared between mollusc species across harvesting sites in England and Wales. Cefas/FSA internal report.

List of Abbreviations

ADCP	Acoustic Doppler Current Profiler
AONB	Area of Outstanding Natural Beauty
BMPA	Bivalve Mollusc Production Area
CD	Chart Datum
Cefas	Centre for Environment Fisheries & Aquaculture Science
CFU	Colony Forming Units
CSO	Combined Sewer Overflow
CZ	Classification Zone
Defra	Department for Environment, Food and Rural Affairs
DWF	Dry Weather Flow
EA	Environment Agency
E. coli	*Escherichia coli*
EC	European Community
EEC	European Economic Community
EO	Emergency Overflow
FIL	Fluid and Intravalvular Liquid
FSA	Food Standards Agency
GM	Geometric Mean
IFCA	Inshore Fisheries and Conservation Authority
ISO	International Organization for Standardization
km	Kilometre
LEA (LFA)	Local Enforcement Authority formerly Local Food Authority
M	Million
m	Metres
ml	Millilitres
mm	Millimetres
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MPN	Most Probable Number
NM	Nautical Miles
NRA	National Rivers Authority
NWSFC	North Western Sea Fisheries Committee
OSGB36	Ordnance Survey Great Britain 1936
mtDNA	Mitochondrial DNA
PS	Pumping Station
RMP	Representative Monitoring Point
SAC	Special Area of Conservation
SHS	Cefas Shellfish Hygiene System, integrated database and mapping application
SSSI	Site of Special Scientific Interest
STW	Sewage Treatment Works
UV	Ultraviolet
WGS84	World Geodetic System 1984

Glossary

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

	cycle to the volume of water flowing up the estuary through a given cross section during the flood tide.
Geometric mean	The geometric mean of a series of N numbers is the N^{th} root of the product of those numbers. It is more usually calculated by obtaining the mean of the logarithms of the numbers and then taking the anti-log of that mean. It is often used to describe the typical values of skewed data such as those following a log-normal distribution.
Hydrodynamics	Scientific discipline concerned with the mechanical properties of liquids.
Hydrography	The study, surveying, and mapping of the oceans, seas, and rivers.
Lowess	Locally Weighted Scatterplot Smoothing, more descriptively known as locally weighted polynomial regression. At each point of a given dataset, a low-degree polynomial is fitted to a subset of the data, with explanatory variable values near the point whose response is being estimated. The polynomial is fitted using weighted least squares, giving more weight to points near the point whose response is being estimated and less weight to points further away. The value of the regression function for the point is then obtained by evaluating the local polynomial using the explanatory variable values for that data point. The LOWESS fit is complete after regression function values have been computed for each of the *n* data points. LOWESS fit enhances the visual information on a scatterplot.
Telemetry	A means of collecting information by unmanned monitoring stations (often rainfall or river flows) using a computer that is connected to the public telephone system.
Secondary Treatment	Treatment to applied to breakdown and reduce the amount of solids by helping bacteria and other microorganisms consume the organic material in the sewage or further treatment of settled sewage, generally by biological oxidation.
Sewage	Sewage can be defined as liquid, of whatever quality that is or has been in a sewer. It consists of waterborne waste from domestic, trade and industrial sources together with rainfall from subsoil and surface water.
Sewage Treatment Works (STW)	Facility for treating the waste water from predominantly domestic and trade premises.
Sewer	A pipe for the transport of sewage.
Sewerage	A system of connected sewers, often incorporating inter-stage pumping stations and overflows.
Storm Water	Rainfall which runs off roofs, roads, gulleys, etc. In some areas, storm water is collected and discharged to separate sewers, whilst in combined sewers it forms a diluted sewage.
Waste water	Any waste water but see also “sewage”.

Acknowledgements

Dale Bruce (New Forest District Council),