Cefas

EC Regulation 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SANITARY SURVEY REPORT

The Solent

2013

Cover photo: Oyster sampling in the Solent

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STATEMENT OF USE: This report provides a sanitary survey for bivalve molluscs in the Solent, as required under EC Regulation 854/2004. It provides an appropriate hygiene classification zoning and monitoring plan based on the best available information with detailed supporting evidence. The Centre for Environment, Fisheries & Aquaculture Science (Cefas) undertook this work on behalf of the Food Standards Agency (FSA).

CONSULTATION:

Consultee	Date of consultation	Date of response
Environment Agency	19/04/2013	-
Isle of Wight Council	19/04/2013	-
New Forest District Council	19/04/2013	-
Portsmouth Port Health	19/04/2013	-
Southampton Port Health	19/04/2013	-
Southern IFCA	19/04/2013	21/05/2013
Southern Water	19/04/2013	-

RECOMMENDED BIBLIOGRAPHIC REFERENCE: Cefas, 2013. Sanitary survey of the Solent. Cefas report on behalf of the Food Standards Agency, to demonstrate compliance with the requirements for classification of bivalve mollusc production areas in England and Wales under of EC Regulation No. 854/2004.

CONTENTS

1. INTRODUCTION

1.1 LEGISLATIVE REQUIREMENT

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

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

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

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

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

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

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

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

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

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

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

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

This report documents the information relevant to undertake a sanitary survey for native oysters (*Ostrea edulis*), Manila clams (*Tapes* spp.), American hard clams (*M. mercenaria*), cockles (*Cerastoderma edule*), razors (*Ensis* spp.) and king scallops (*Pectens maximus*) within the Solent. The area was prioritised for survey in 2013 by the FSA as a major oyster fishery.

1.2 AREA DESCRIPTION

The Solent is situated between the south coast of England and the Isle of Wight. Its shores are heavily populated, and it is a busy waterway used by commercial shipping, yachts and fishing boats. It is approximately 32km in length from east to west and adjoins several separately defined estuaries and harbours. The survey area includes about 170km^2 of classified waters, many individual shellfish beds, and multiple and diverse sources of microbiological contamination. It excludes Lymington River, Beaulieu River, Medina Estuary, Langstone Harbour, Portsmouth Harbour and Southampton Water, which are adjacent estuaries defined as separate production areas under the shellfish hygiene classification programme. The Solent used to support what was considered to be Europe's largest self-sustaining oyster fishery, but following a series of recruitment failures since 2006, the population is now severely reduced.

Figure 1.1. Location of the Solent

CATCHMENT

Figure 1.2 shows the land cover within the hydrological catchment draining to the survey area.

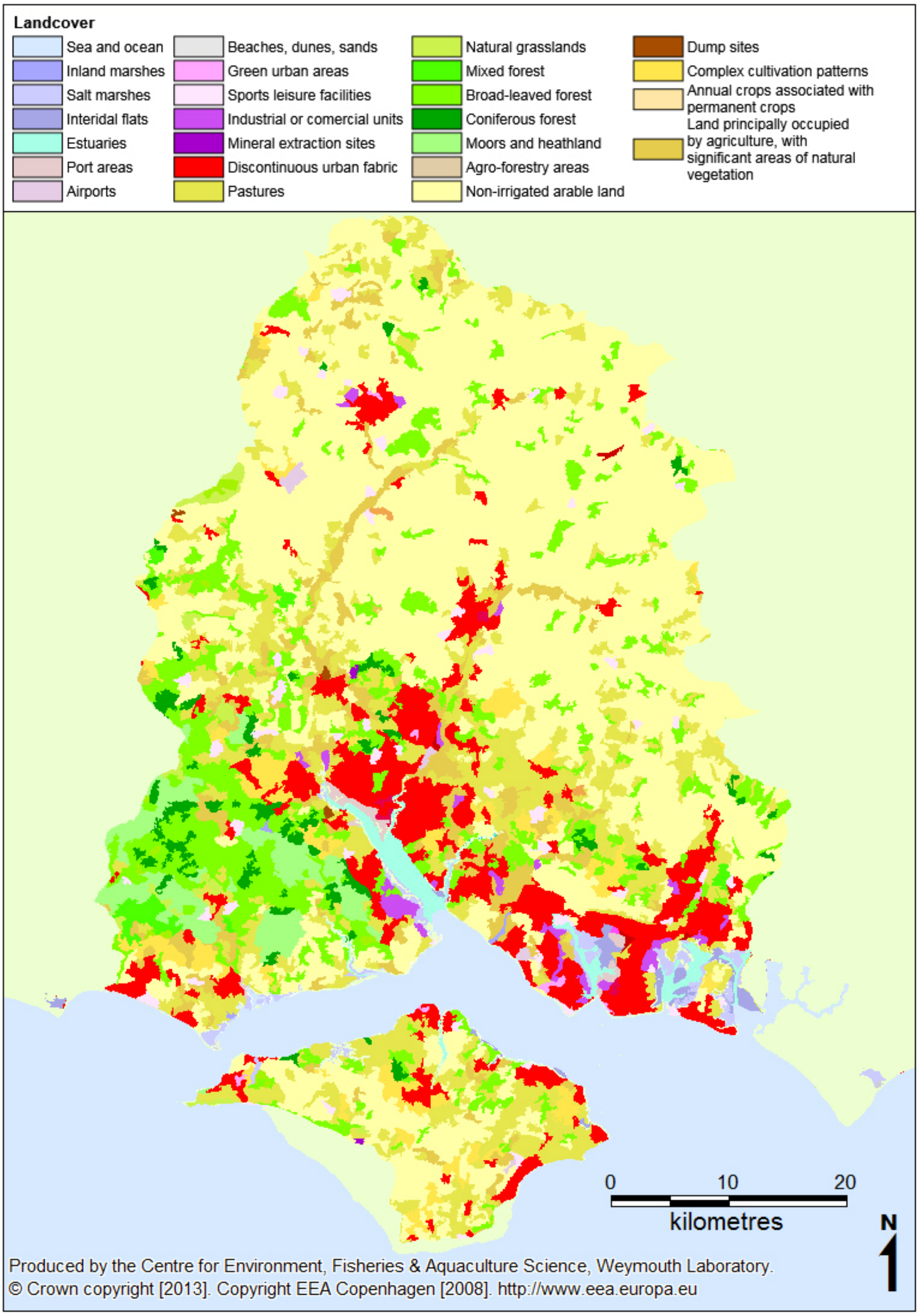

Figure 1.2 Land cover in the Solent catchment area

The Solent catchment covers an approximate area of 3,125km² and is made up of several separate sub catchments (Figure 1.1). The Rivers Test, Itchen, Hamble Lymington, Beaulieu and Meon are the main freshwater inputs, although the first three discharge to Southampton Water rather than the Solent itself. The catchment supports a range of different land uses. On the mainland there is a clear divide between urban and rural land uses, with urbanised areas concentrated by the coast at Southampton and Portsmouth. The upper catchment is mainly arable farmland with some pastures, small villages and natural areas. The New Forest is a large area of mixed woodland, moors and heathland situated in the south west of the catchment. Large areas of arable land and pastures, and smaller pockets of mixed woodland exist in the north east, within the South Downs National Park. The Isle of Wight is predominantly rural comprising mainly of arable land and pastures with small urbanised areas constrained to north and eastern coasts, representing the towns of Cowes, Newport, Ryde and Shanklin.

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

The Solent catchment comprises of chalk and London Clay in the north, and sands, clays and Bembridge limestone to the south. The Isle of Wight mirrors this and comprises of sand, clays and Bembridge limestone to the north and London Clay and chalk to the south (Natural England, 2013).

2. RECOMMENDATIONS

NATIVE OYSTERS

The following 10 zones are proposed for native oysters, each of which has one RMP (Figures 3.1 and 3.2, Table 3.1). It is recognised that stocks may be sparse or absent from the exact RMP locations specified so some slight adjustments may be required following the first sampling runs. Where appropriate, existing or former RMPs are used as these are known to have held stocks in recent times.

Yarmouth to Newtown. Stocks here are very sparse at present and the area was not fished commercially last season. As such the area may be a candidate for temporary declassification whether the fishery is closed or not. The main sources of contamination are via the Yarmouth estuary direct to the zone and the Newtown River estuary just to the east. The Newtown River is the larger of the two watercourses, and receives sewage from three small works. Its estuary lies to the east of this zone so its ebb plume will be carried into the zone. Its larger estuary and position outside of the zone offers more scope for dilution. The Yarmouth estuary is more urbanised, receives sewage from one small sewage works and has several intermittent discharges to it or adjacent coastal areas. It is much more heavily used by yachtsmen, offers less scope for dilution and discharges direct to the zone. There is currently one active RMP in this zone (Yarmouth West) which is well positioned to capture the ebb plume from the Yarmouth estuary. In the adjacent zone there is an RMP positioned by the mouth of the Newtown River, which returned very similar results but with a slightly lower average and peak result. It is therefore recommended that the Yarmouth West RMP be retained for this zone.

Newtown to Cowes. Stocks here are very sparse at present and the area was not fished commercially last season. As such the area may be a candidate for temporary declassification whether the fishery is closed or not. Stocks are not thought to extend as far east as Gurnard. The main sources of contamination are the Newtown River estuary in the western end, The Thorness Bay Holiday Park STW outfall, a cluster of intermittent discharges from Gurnard to Cowes, some of which have spilled for more than 5% of the time in recent years, and several watercourses of varying size, some of which were carrying high bacterial loadings at the time of shoreline survey. The ebb plume from the Medina may also be of some influence at the eastern end of the zone. It is therefore likely that the eastern end of the shellfish beds are subject to higher levels of contamination, with a secondary hotspot around the Newtown River mouth. There are currently two active RMPs at Newtown River Mouth and Thorness. No significant difference in average results was seen between the two, although Thorness had slightly higher average and peak results. It is therefore recommended an RMP be created at Thorness Bay to better capture the plume from the Thorness Bay sewage outfall, as well as from various shoreline sources to the east.

Keyhaven to Lymington. Stocks here are very sparse at present and the area was not fished commercially last season. As such the area may be a candidate for temporary declassification whether the fishery is closed or not. Production area boundaries should be adjusted slightly to include the full extent of the Lymington oyster bed. The main sources of contamination are the Pennington STW outfall, the ebb plumes from the Keyhaven and Lymington, and two smaller watercourses to the east. The most concentrated source to this zone is likely to be the Pennington STW, which discharges within or in very close proximity to an oyster bed in only about 2m of water. Of the watercourses the Lymington is the largest and receives the highest volumes of sewage. This zone currently contains two active RMPs (South West Sewer Outfall and East Lymington River). Results from the two were similar in terms of average and peak results, and were correlated on a sample by sample basis, although the South West Sewer Outfall recorded a slightly higher average and peak result. It is therefore recommended that the RMP at South West Sewer Outfall be maintained as this is best placed to capture any hotspot around the Pennington Outfall and will also capture the remnants of the ebb plume from the Lymington River.

<u>Off Beaulieu.</u> Stocks here are very sparse at present and the area was not fished commercially last season. As such the area may be a candidate for temporary declassification whether the fishery is closed or not. The main source of contamination is the ebb plume from the Beaulieu. This estuary receives runoff from the Beaulieu catchment, the effluent from three minor sewage works and is heavily used by yachtsmen. There are further significant watercourses discharging to the eastern shore of the mouth of the Beaulieu and one just to the west of the zone. There is a very small primary treated sewage outfall at Thorn Beach. There is only one active RMP within this zone, at Off Lepe. The ebb plume from Southampton Water may also be of significance towards the western end of this zone. It is recommended that the RMP be relocated to Beaulieu River Mouth, to best capture contamination originating from the Beaulieu Estuary. This would also be effective in capturing the ebb plume from Southampton Water.

<u>Stanswood, Calshot, Thorn Knoll and Bramble.</u> Stocks here are sparse at present, and the public areas were not fished commercially last season. There is a Several Order at Stanswood which may require continued classification irrespective of any closures to the public fishery. The main source of contamination here is the ebb plume from Southampton Water. The ebb plume from the Beaulieu will be carried west away from this zone. There are two minor watercourses discharging to the shore of this zone. There is also an intermittent discharge at Calshot (Calshot Car Park CSO) which is monitored but did not record any spills in the period 2009 to March 2012. There is a mid-sized sewage works (Ashlett Creek STW) discharging to the west shore of Southampton Water about 1km up-estuary from the boundary of this zone. Currently there is one active RMP in this zone (Off Stanswood) which has been monitored since 2009. Before this RMP was established there were two separate RMPs at Stanswood and Calshot but these were abandoned in 2009. Between the former RMPs at Stanswood and Calshot, results were slightly higher on average at Calshot, but not significantly so, and the highest individual result arose at Stanswood. Results showed a significant correlation on a sample by sample basis. The average result was higher at Off Stanswood than at either Stanswood or Calshot but was sampled through a different period. Overall there was no strong gradient of increasing contamination towards the east across these three RMPs. Nevertheless it is recommended that the RMP be relocated to Calshot Spit to best capture the ebb plume from Southampton Water.

<u>Cowes to Ryde Pier.</u> Oyster beds within this zone saw some commercial activity last season, so assuming the fishery remains open, this zone is likely to require continued classification. There are several watercourses of varying size draining to this zone. The largest of these are Palmers Brook and Wootton Creek. Only Wootton Creek has a defined estuary, and the others flow across the beach. Wootton Creek is heavily used by yachtsmen. There is a cluster of intermittent discharges to Wootton Creek of which three are monitored. Although these three did record spills from 2009 to March 2012 the frequency of spills was very low (0.5% or less). There is a further cluster of five intermittent discharges in the Ryde/Binstead area, of which four are monitored. Two did not record any spills, one spilled for <0.1% of the time and one spilled for 2.1% of the time (from 2009 to March 2012). The latter (Binstead Ladies Walk CSO) discharges to the stream flowing through Binstead. There are three active native oyster RMPs within this zone (Osbourne Bay, Kings Quay and Ryde Pier) and an old RMP with a considerable monitoring history up to 2010 (Mother Bank Church Spire). Across these results were broadly similar with highest average and peak results at Kings Quay. No results exceeding 4600 were recorded at Osbourne Bay. Results at Osbourne Bay were correlated with both Kings Quay and Mother Bank Church Spire on a sample by sample basis, but no other site pairings had sufficient paired samples to undertake further analyses. On balance a new RMP located just to the west of the mouth of Wootton Creek should capture contamination from both Wootton Creek and Palmers Brook.

<u>Warner.</u> This is a discrete bed which was subject to some commercial activity last season, so assuming the fishery remains open, this zone is likely to require continued classification. The current boundaries should be revised to include the bed in its entirety. There are a few minor watercourses discharging direct to this zone and three intermittent discharges, all of which are monitored and none of which spilled for more than 0.4% of the time (2009 to March 2012). The Budds Farm STW long sea outfall discharges just over a kilometer to the east of this zone, but the plume from this will usually be carried past the Warner bed about 2km north of it by tidal streams. The eastern Yar, which is a significant watercourse receiving sewage from 8 minor sewage works, discharges to the eastern coast of the Isle of Wight via Bembridge Harbour, about 2km to the south of the Warner bed. The ebb tide will carry any plume from here towards the bed. This area has never been sampled for hygiene classification purposes. It is therefore recommended that a new RMP be established at the southern inshore tip of this bed to best capture contamination originating from the Yar.

<u>Chilling to Gillkicker Point.</u> Oyster beds within this zone saw some commercial activity last season, so assuming the fishery remains open, this zone is likely to require continued classification. The recognised shellfish beds do not extend east of Browndown Point. The most concentrated continuous source of contamination direct to this zone is the Peel Common STW. Nine intermittent sewage outfalls discharge direct to this zone, of which 8 are monitored and none of these spilled for more than 0.3% of the time (2009 to March 2012). There are three watercourses discharging to this zone, the largest of which is the Meon, which does not have a significant estuary. The ebb plume from Southampton Water will not impact on this zone, but any plume from Portsmouth Harbour will. There are two active RMPs within this zone (Off Browndown and Gillkicker Point). Results were slightly more variable off Browndown, but there were fewer low results at Gillkicker Point where results were

higher on average. There was no significant difference in average result between the two however, and results were correlated on a sample by sample basis. It is recommended that the RMP be relocated to the eastern edge of the Browndown bed in the path of any plume from Peel Common STW.

Spit Sand. Oyster beds within this zone saw some commercial activity last season, so assuming the fishery remains open, this zone is likely to require continued classification. The Peel Common STW outfall discharges about 2.5km to the west of this zone but its plume will be carried into the zone during the flood tide. The Budds Farm STW outfall lies 2km to the south east of this zone but tidal stream will advect it past this zone to its south. There are no significant watercourses and no intermittent sewage discharges direct to this zone. The ebb plume from Portsmouth Harbour is likely to be a significant influence. An RMP located at Spit Sand South should be effective at catching the remnants of any plumes from both Peel Common STW and Portsmouth Harbour.

Ryde Middle and Sturbridge. Oyster beds within this zone represent the largest remaining concentrations within the production area, and were subject to commercial activity in the previous season. This zone will therefore require continued classification if the fishery remains open for next season. The Budds Farm STW outfall lies to the east of this zone, and contamination from this will be advected towards the Sturbridge bed, albeit 6km distant. There is also an intermittent discharge via long sea outfall direct to Sturbridge Shoal (Ryde Appley Park Headworks PS). This is a significant spiller, which was active for 9.5% of the time (2009 to January 2012). Even at this frequency, a spill would only be captured about once a year with monthly monitoring. Nevertheless it is recommended that a new RMP be established at Sturbridge in the immediate plume of any spills from this outfall. This would also be in the approximate path of any plume from the Budds Farm STW outfall.

Sampling frequency, methods and tolerance. The sampling frequency should be monthly and year round ideally. It will be possible to maintain full classifications without sampling the first two months of the closed season (March and April) as long as 10 samples are submitted per year. The sampling method should be via dredge and the species sampled should be native oysters of a harvestable size (>70mm). A tolerance of 250m should be sufficient to allow dredging of sufficient specimens for a sample in most cases. The LEA may wish to consider temporary declassification (via quarterly sampling) of some zones within the western Solent, although industry representatives should be consulted beforehand. Should the fishery be temporarily closed for next season the entire area may be considered for temporary declassification, with the exception of the fishery order at Calshot. A decision on the closure is due to be made at the June meeting of the Southern IFCA committee.

KING SCALLOPS

There is a small scallop bed somewhere in the immediate vicinity of No Mans Land Fort which has been subject to fairly heavy commercial activity over the last three winters. The bed is reported to be no more than 200m across. There is a small private consented discharge from the fort, although it is uncertain whether it is in regular use. The zone lies directly in the path of the plume from Budds Farm STW on the ebb tide, about 2.5km away. An RMP located within the scallop bed, and as close to the fort as possible would adequately capture contamination from the identified sources (Figure 3.3 and Table 3.1).

As these scallops are not located within an unclassified area, in accordance with the legislation, they will require classification themselves, rather than end product testing typically applied to offshore scallop beds. It is uncertain whether native oysters represent a suitable surrogate, and the scallop bed lies a considerable distance from the nearest oyster bed. Scallops should therefore be sampled to establish a classification for this bed. Sampling should be via dredge, and should be of market size (>110mm) scallops. It should be undertaken on a monthly, year round basis. Given the small size of the scallop bed a tolerance of 50m should be sufficient. It may be possible for a preliminary classification to be established for this bed based on native oyster sample results, on request of the LEA.

CLAMS

The only commercial clam harvesting area is currently at Chilling (Figure 3.4) where the majority of stocks are Manila clams, with occasional native clams and American hard clams forming bycatch. There is one watercourse discharging directly to this area, and the larger River Meon discharges to the shore just east. An RMP located on the beach by Brownwich Farm, in the path of any drainage channel that the stream cuts across the intertidal, should represent peak levels of contamination within this zone.

This area is not currently classified for Manila clams, and these accumulate *E. coli* to higher levels than the other species of clams, so would require monitoring before a classification can be issued. As they form the vast majority of catches, and whatever classification they receive will dictate how the catch is marketed, there seems little point in sampling the other species. A classification for all clam species based on Manila clams will be fully protective of public health.

Sampling may be via hand or dredge, and a tolerance of 100m applies. The species sampled should be Manila clams of a market size (38mm). Sampling frequency should be monthly and year round. The LEA should note that this clam bed coincides with a seagrass bed so harvesting (and sampling) from here may be banned in the near future (see below).

COCKLES

There is currently no commercial activity for cockles within the Solent, although there are some stocks in the intertidal areas at Chilling, Ryde and Kings Quay Beach. It is possible that at some point there may be renewed commercial interest in these stocks, although they will only be legally exploitable via hand gathering. The following three zones are proposed (Figure 3.5) although they only need sampling if the industry requests their classification or intelligence suggests they are being exploited commercially.

<u>Chilling.</u> There is one watercourse discharging directly to this area, and the larger River Meon discharges to the shore just east. An RMP located on the beach by

Brownwich Farm, in the path of any drainage channel that the stream cuts across the intertidal should represent peak levels of contamination within this zone.

Ryde. There are three small watercourses discharging to this zone, the largest of which is Monktonmead Brook. This receives four intermittent discharges all of which are monitored and did record some spills, but none spilled for more than 0.4% of the time (2009 to March 2012). Additionally there is a further intermittent sewage discharge at the eastern end of the zone, which is monitored and did not record any spills between 2009 and March 2012. It is therefore recommended that the RMP is located as close as possible to the path that Monktonmead Brook follows across the intertidal (Ryde Harbour).

Kings Quay Beach. There is one main watercourse discharging to this area (Palmers Brook), and Wootton Creek lies immediately to the east so the ebb plume from this inlet will impact within this zone. Wootton Creek discharges outside this zone and contamination from here has significant scope for dilution before reaching the zone. It is therefore recommended that the RMP be located on the intertidal as close as is possible to the drainage channel Palmers Brook follows across the intertidal (Kings Quay Creek).

Sampling frequency, methods and tolerance. Sampling should be via hand, and a tolerance of 100m applies. The species sampled should be cockles of a market size (38mm). Sampling frequency should be monthly, although the first two months of the closed season may be missed (February and March), assuming all 10 other months are sampled. All three of these zones coincide to varying extents with seagrass beds.

RAZORS

Razor stocks are no longer present off Ryde so these will not require classification in future. Kings Quay Beach may possibly require classification in the future (Figure 3.6) although stock status here is uncertain.

The same RMP location should be used as for cockles if possible (Kings Quay Creek) although it is recognised that razors are likely to be lower down the intertidal. Sampling should be via hand, and a tolerance of 100m applies. The species sampled should be razors (*Ensis* spp.) of a market size. Sampling frequency should be monthly and year round.

SEAGRASS BEDS

It is likely that the seagrass beds, as shown in Figure 4.1, will be subject to bans on dredging and shellfish digging sometime in 2013. If and when such bans come into force it is recommended that these protected areas are declassified, as no shellfish could be legally harvested from them and their continued classification may send mixed messages to the industry.

3. SAMPLING PLAN

GENERAL INFORMATION

Location Reference

Production Area	Solent
Cefas Main Site Reference	M24
Ordnance survey 1:25,000 map	Landranger 22, 29 & 119
Admiralty Chart	2045

Shellfishery

Species/culture	Native oysters Manila & native clams (*Tapes* spp.) Amercian hard clams King scallops Cockles	Wild
Seasonality of harvest	November to February (native oysters) May to January (cockles) Year round (all other species)	

Local Enforcement Authorities

Name	Southampton Port Health Authority City Depot and Recycling Park First Avenue Southampton SO15 OLJ
Environmental Health Officer	Kelly Scott
Telephone number ☎	02380 226631
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Name	Portsmouth Port Health Authority Public Protection Services Civic Offices Guildhall Square Portsmouth Hampshire PO1 2PQ
Environmental Health Officer	Dave Jones
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Name	Environment Health Offices Isle of Wight Council Jubilee Stores The Quay Newport Isle of Wight PO30 2EH
Environmental Health Officer	Rachel Mooney
Telephone number ☎	01983 823000
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Name	New Forest District Council Town Hall Avenue Road Lymington Hampshire SO41 9ZG
Environmental Health Officer	Dale Bruce
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Requirement for Review

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

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

Classification zone	RMP	RMP name	NGR	Latitude & Longitude (WGS84)	Species Sampled	Growing method	Harvesting technique	Sampling method	Tolerance	Frequency	Comments
Yarmouth to Newtown	B024N	Yarmouth West	SZ 3480 9020	50°42.62'N 01°30.51'W	Native oysters	Wild	Dredge	Dredge	250m	Monthly	Existing RMP. Possible candidate for temporary declassification due to stock status
Newtown to Cowes	B24BF	Thorness Bay	SZ 4520 9410	50°44.69'N 01°21.64'W	Native oysters	Wild	Dredge	Dredge	250m	Monthly	New RMP. Possible candidate for temporary declassification due to stock status
Keyhaven to Lymington	B24AN	South West Sewer Outfall	SZ 3282 9151	50°43.30'N 01°32.10'W	Native oysters	Wild	Dredge	Dredge	250m	Monthly	Existing RMP. Possible candidate for temporary declassification due to stock status
Off Beaulieu	B24BG	Beaulieu River Mouth	SZ 4435 9750	50°46.52'N 01°22.34'W	Native oysters	Wild	Dredge	Dredge	250m	Monthly	New RMP. Possible candidate for temporary declassification due to stock status
Stanswood, Calshot, Thorn Knoll and Bramble	B24BH	Calshot Spit	SU 4931 0183	50°48.84'N 01°18.09'W	Native oysters	Wild	Dredge	Dredge	250m	Monthly	New RMP. Will possible require continued classification even if Solent oyster fishery is temporarily closed.
Cowes to Ryde Pier	B24BI	Wootton Creek Mouth	SZ 5552 9392	50°44.53'N 01°12.87'W	Native oysters	Wild	Dredge	Dredge	250m	Monthly	New RMP
Warner	B24BJ	Warner South	SZ 6400 9091	50°42.86'N 01°5.69'W	Native oysters	Wild	Dredge	Dredge	250m	Monthly	New RMP. Zone currently partly unclassified.

Chilling to Gilkicker Point	B24BK	Browndown	SZ 5747 9794	50°46.69'N 01°11.17'W	Native oysters	Wild	Dredge	Dredge	250m	Monthly	New RMP
Spit Sand	B24BL	Spit Sand South	SZ 6195 9676	50°46.03'N 01°7.37'W	Native oysters	Wild	Dredge	Dredge	250m	Monthly	New RMP
Ryde Middle and Sturbridge	B24BM	Sturbridge	SZ 5973 9543	50°45.32'N 01°9.28'W	Native oysters	Wild	Dredge	Dredge	250m	Monthly	New RMP
No Mans Land Fort	B24BN	No Mans Land Fort	SZ 6396 9376	50°44.40'N 01°5.70'W	King Scallops	Wild	Dredge	Dredge	50m	Monthly	New RMP. Zone currently unclassified.
Chilling	B24BO	Brownwich Farm	SU 5169 0330	50°49.62'N 01°16.05'W	*Tapes* spp.	Wild	Hand or dredge	Hand or dredge	100m	Monthly	New RMP. May be used to also represent American hard clam which is a bycatch here. Zone currently unclassified for *Tapes* spp.
Chilling	B24BP	Brownwich Farm	SU 5169 0330	50°49.62'N 01°16.05'W	Cockles	Wild	Hand	Hand	100m	Monthly	New RMP (if required). Zone currently unclassified.
Ryde	B24BQ	Ryde Harbour	SZ 6001 9291	50°43.96'N 01°9.063'W	Cockles	Wild	Hand	Hand	100m	Monthly	New RMP (if required). Zone currently unclassified.
Kings Quay Beach	B24BR	Kings Quay Creek	SZ 5398 9422	50°44.71'N 01°14.18'W	Cockles	Wild	Hand	Hand	100m	Monthly	New RMP (if required). Zone currently unclassified.
Kings Quay Beach	B24BS	Kings Quay Creek	SZ 5398 9422	50°44.71'N 01°14.18'W	*Ensis* spp.	Wild	Hand	Hand	100m	Monthly	New RMP (if required). Zone currently unclassified.

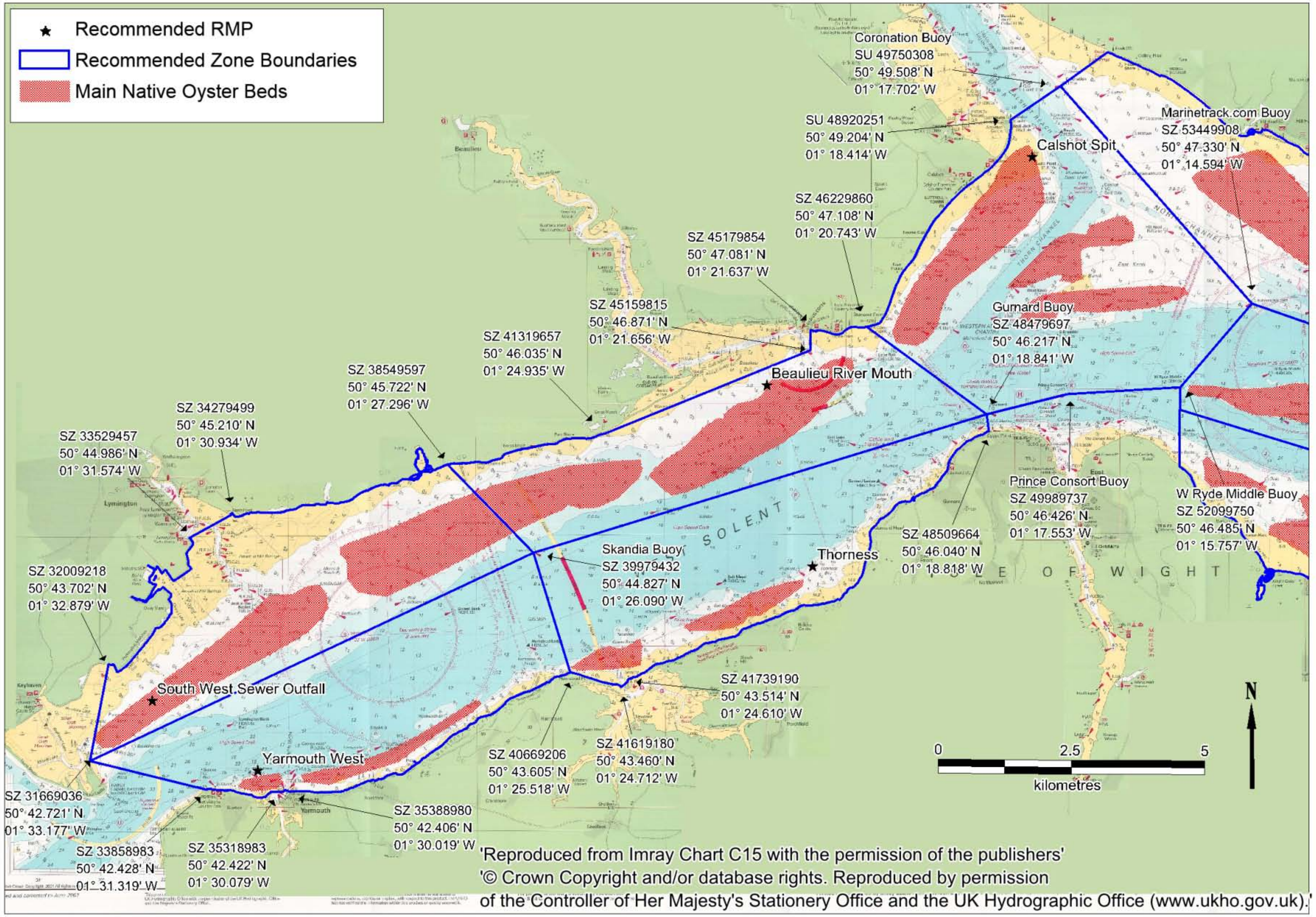


Figure 3.1 Recommended classification zone boundaries and RMP locations for native oysters (eastern Solent)

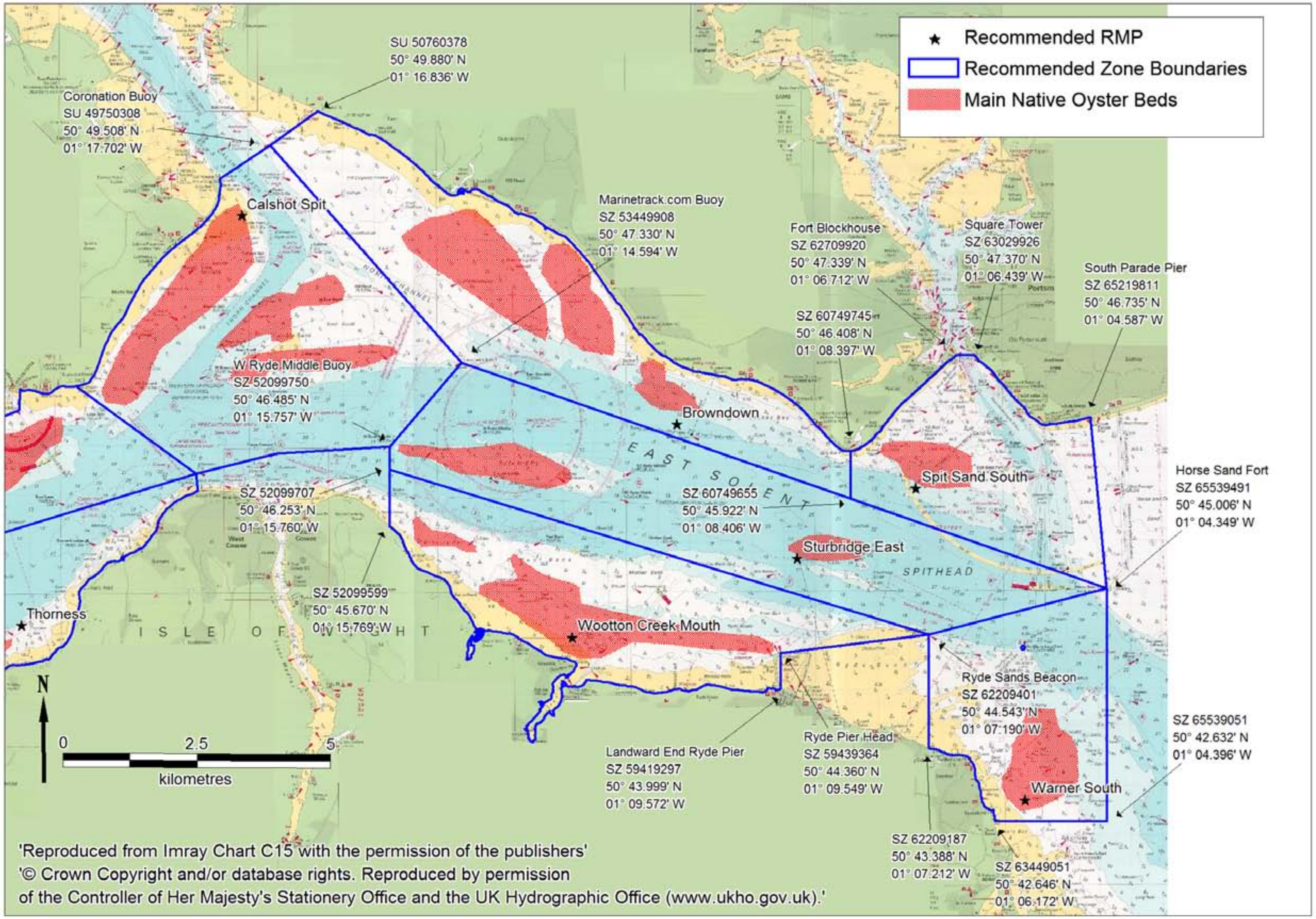


Figure 3.2 Recommended classification zone boundaries and RMP locations for native oysters (western Solent)

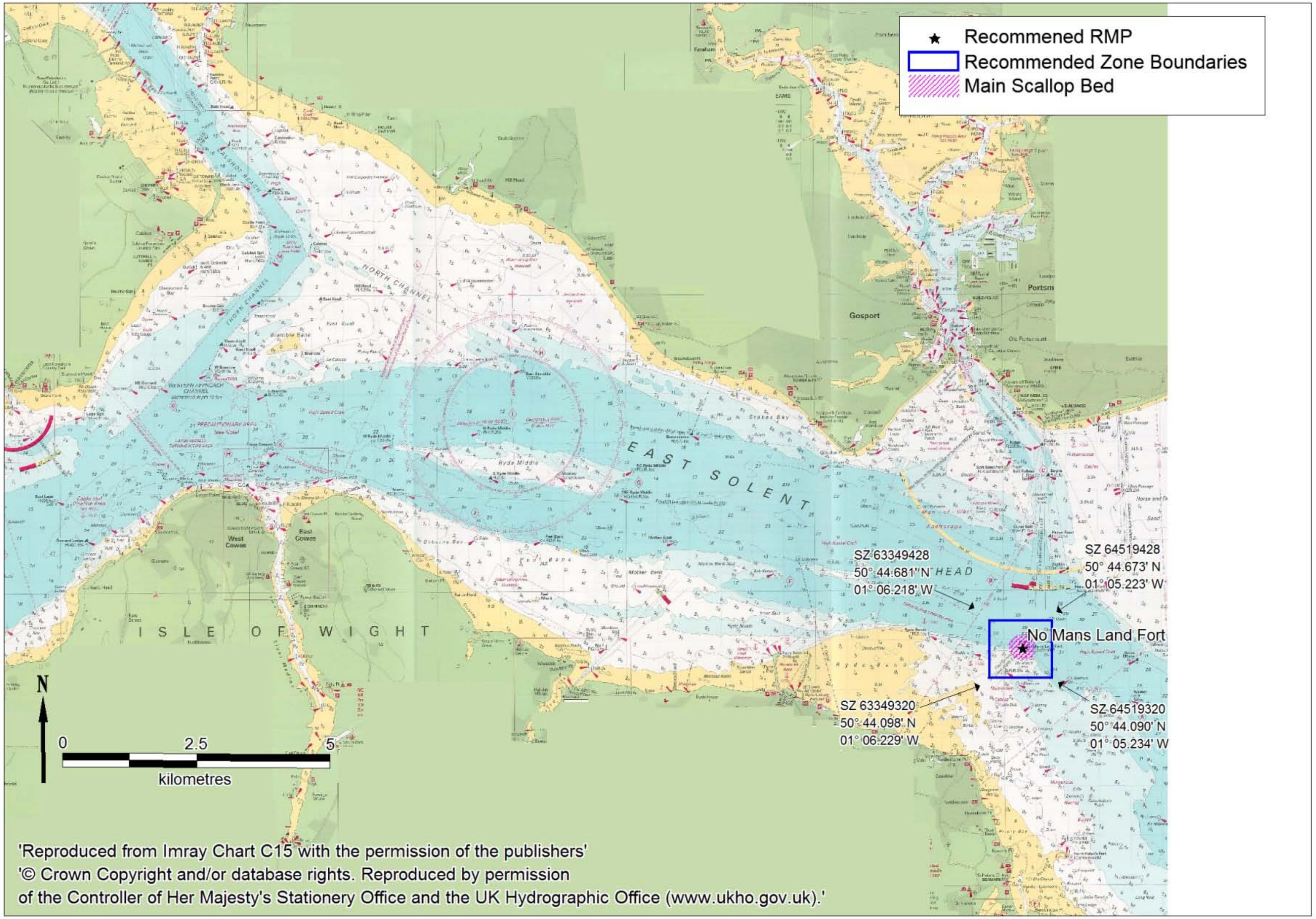


Figure 3.3 Recommended classification zone boundaries and RMP locations for king scallops

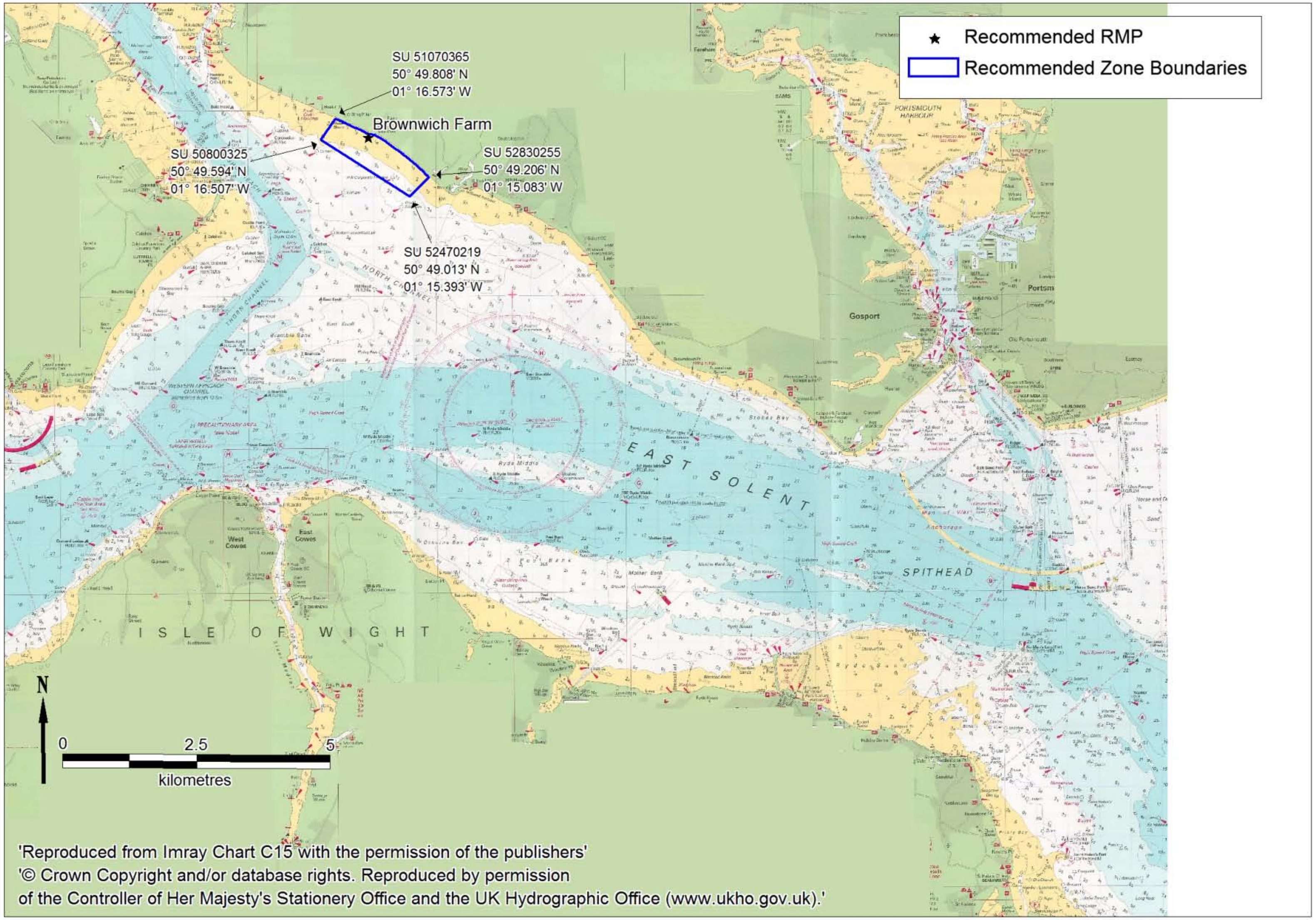


Figure 3.4 Recommended classification zone boundaries and RMP locations for clams

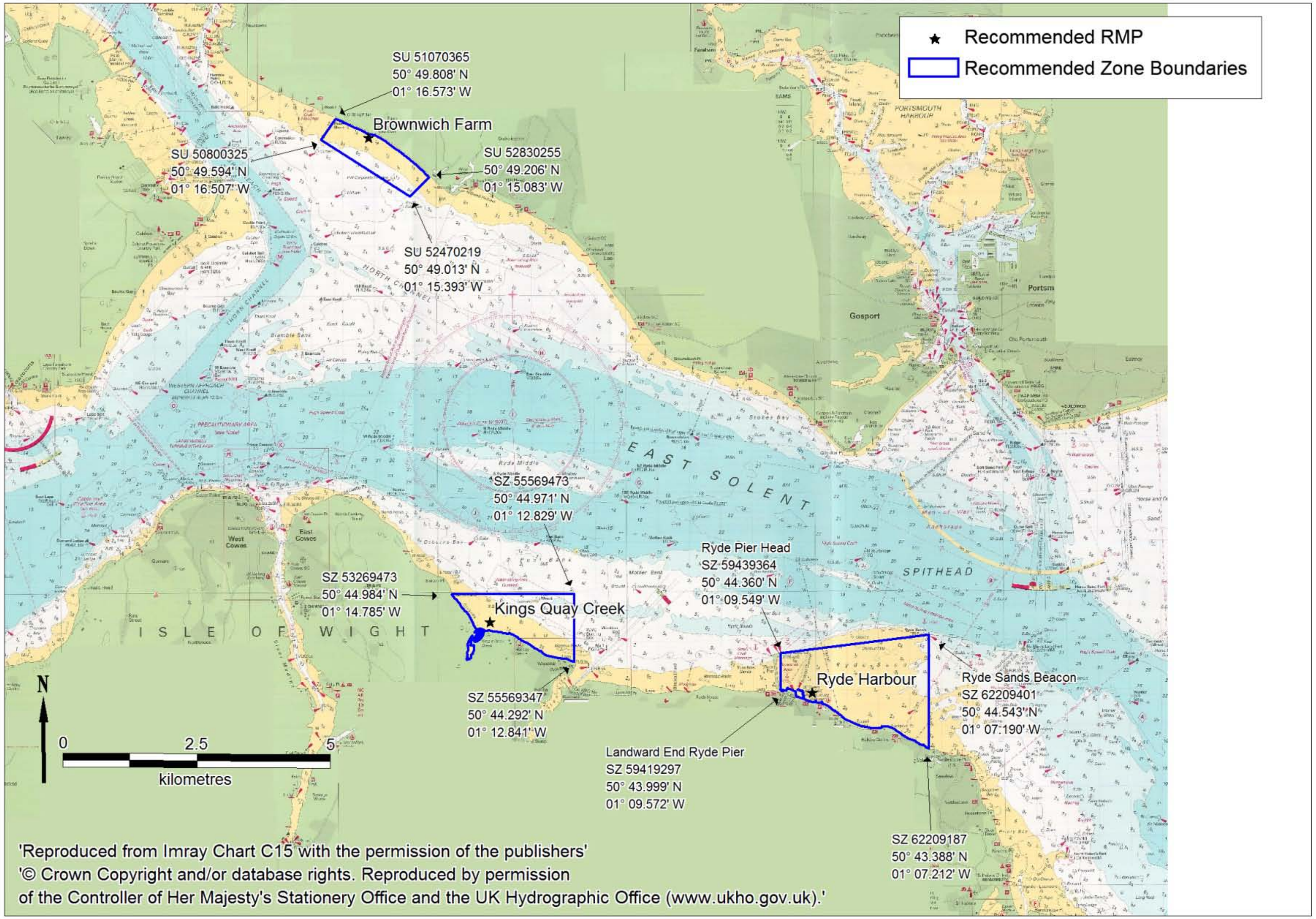


Figure 3.5 Recommended classification zone boundaries and RMP locations for cockles (if required)

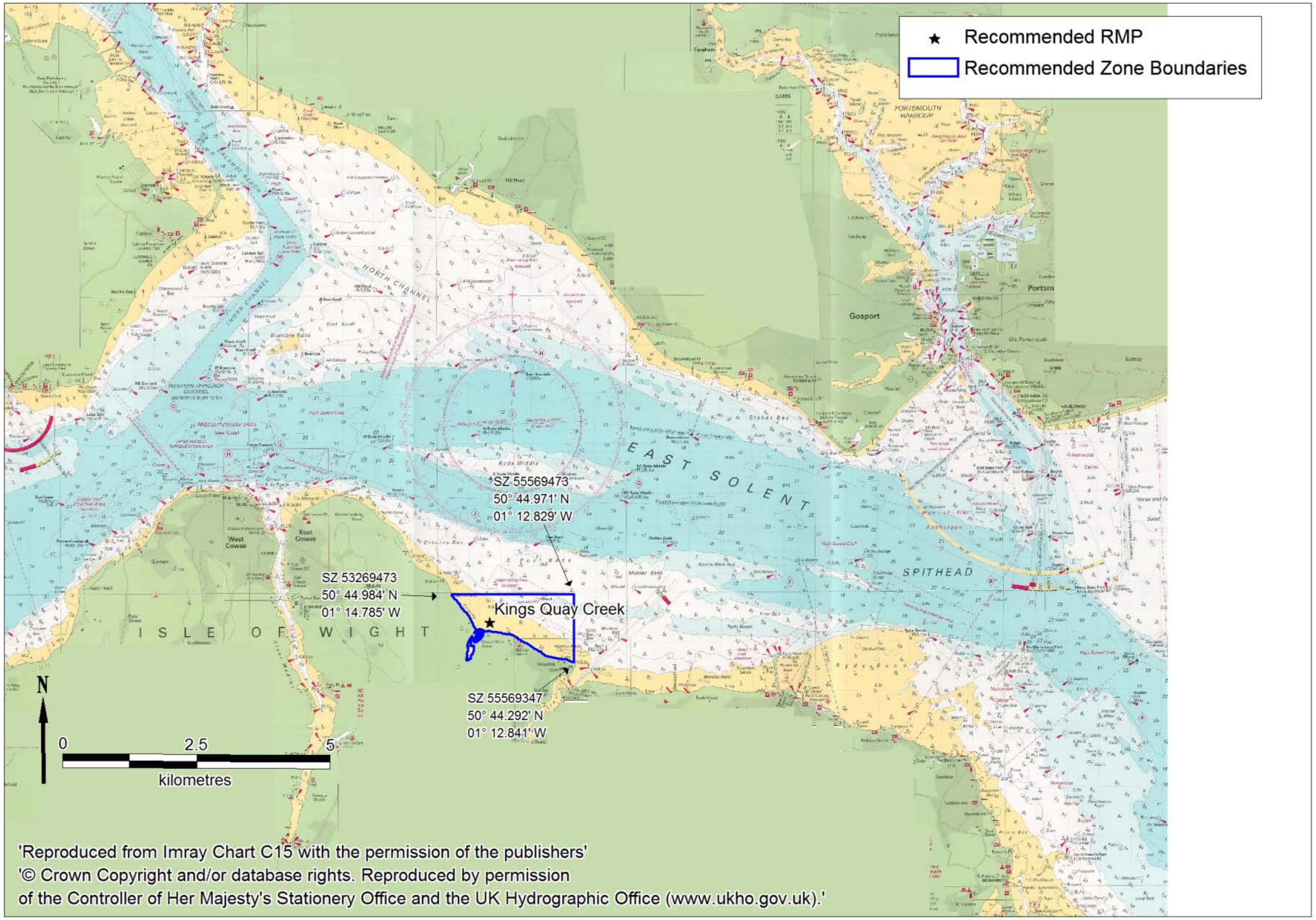


Figure 3.6 Recommended classification zone boundaries and RMP locations for razors (if required)

4. SHELLFISHERIES

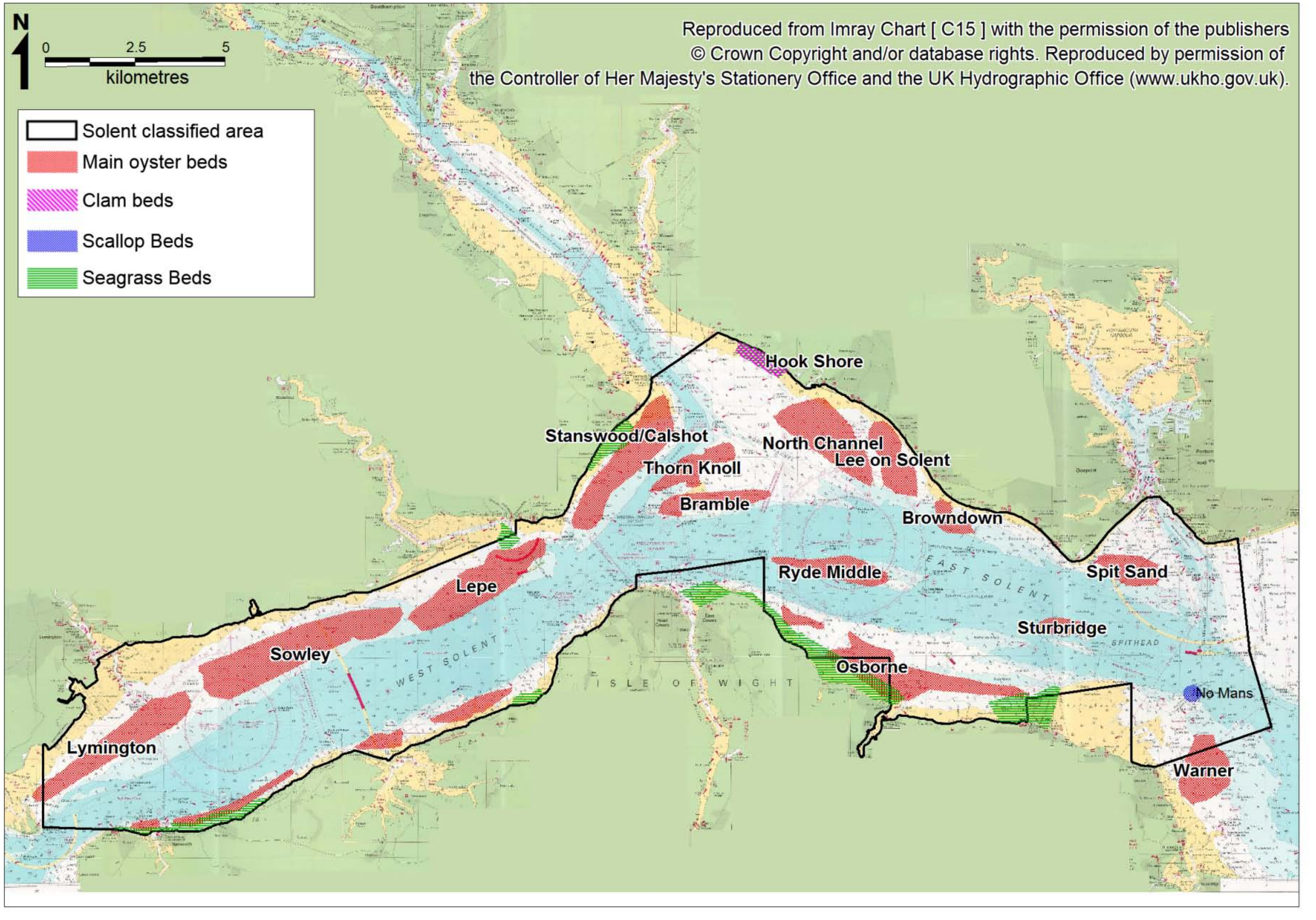
4.1 SPECIES, LOCATION AND EXTENT

The entire Solent is currently classified for the harvest of native oysters, and part of the north east Solent is classified for the harvest of hard clams. As well as these species, there are also Manila clams, cockles, razors and possibly other species of historic and/or potential commercial interest in various locations. Much of the information presented in this section was provided by the Southern IFCA.

NATIVE OYSTERS

Historically, the Solent has supported a major native oyster fishery, which has had a history of peaks and troughs over the decades. The most recent recovery started during the early 1970s, when cultured oysters from the Beaulieu generated a significant spatfall at Stanswood. Oysters then spread throughout the Solent during the 1970s and 1980s to form beds in the approximate areas shown in Figure 4.1, despite quite heavy fishing pressure. The fishery peaked in 1979/80 when about 840 tonnes were landed to Solent ports (Kamphausen, 2012). The Solent Oyster Fishery Order was established in 1980 and introduced management measures such as a shortened season, effort limitation and minimum sizes. Annual oyster surveys have been undertaken from the 1970s through to 2011, although in 2011 the survey was more limited in coverage than for previous years. These surveys have shown that beds in the western Solent were in general decline since the late 1970s, whereas stocks in the eastern Solent increased until 2000, then fluctuated for a few years before declining sharply from 2006 onwards (Vanstaen & Palmer, 2010). The last notable spatfall occurred in 2006. The last full survey undertaken in 2010 concluded that stocks in the western Solent were at very low levels, with beds on the northern shore (Sowley, Lepe and Lymington) almost completely barren. Continuing decline was also reported for beds in the eastern Solent, although stocks here were not quite as low levels as the western Solent. Highest densities were found at Ryde Middle. There was an absence of recruitment throughout the Solent, indicating that fishery prospects will remain poor for at least four or five years. The more restricted survey in 2011 showed a continued decline and no evidence of a successful spatfall, although a few larger oysters remain primarily at Ryde Middle (Palmer and Firmin, 2011).

The Solent Oyster Fishery Order lapsed in 2010 and has not been reinstated, so the fishery is now managed via local byelaws. There is still a fishery order at Stanswood, although there is little or no activity here at present. The adjacent fishery order at Calshot has been given up.


N
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kilometres
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Solent classified area
Main oyster beds
Clam beds
Scallop Beds
Seagrass Beds
Hook Shore
Stanswood/Calshot
North Channel
Lee on Solent
Thorn Knoll
Bramble
Browndown
Ryde Middle
Spit Sand
Lepe
Sturbridge
Sowley
Osborne
No Mans
Lymington
Warner
WEST SOLENT
EAST SOLENT
ISLE OF WIGHT
SPITHEAD

Figure 4.1. Solent shellfisheries

Last oyster season (2012/13) around 30-40 oyster dredgers were active in the general area at the start of the season. In the first week of the season all effort was directed to Chichester Harbour. After this about 10 boats fished Portsmouth Harbour, 10 boats fished Langstone Harbour, and the remainder fished various grounds in the Solent. Within the Solent, effort was mainly directed at Ryde Middle, Sturbridge and Warner. Grounds on the north side at Chilling, Lee on Solent, North Channel and Portsmouth Spit were also fished by a handful of vessels. In mid December most of the remaining vessels (~15) switched to scallop fishing around No Mans Land Fort. One vessel continued to fish oysters through the rest of the season, mainly at Osbourne Bay and on the north Solent grounds. There was no activity on the oyster beds in the western Solent.

CLAMS

The vast majority of clams harvested from the Solent are Manila clams, with occasional specimens of other species such as American hard clams, palourdes and possibly other species forming bycatch. The clam fishery operates in the intertidal area off Chilling. A couple of vessels dredge here, primarily in the winter. The area is also targeted by hand pickers. No clam surveys have been undertaken in recent years so the status and exact distribution of stocks is uncertain.

COCKLES

Cockles are present on the intertidal in some places within the western Solent, with concentrations at Ryde, Kings Quay Beach and Chilling. These fisheries are not thought to be commercially active at present, although some casual gathering occurs off Appley Tower and the edge of the seagrass on the Ryde side, and possibly in other areas. No cockle surveys have been undertaken in recent years so stock status is uncertain.

RAZORS

Razors were harvested commercially at Ryde and Kings Quay Beach but this fishery is not active at present. There is very little stock remaining at Ryde due to erosion of the sands following removal of a redundant CSO pipe here.

SCALLOPS

A significant scallop dredge fishery has emerged over the last three winters on a small area around the No Mans Land Fort. Last December (2012/13) up to 14 boats were fishing the area at any one time. No stock surveys have been undertaken on the scallop grounds so the exact distribution and current status of these stocks are uncertain.

4.2 GROWING METHODS AND HARVESTING TECHNIQUES

All stocks are wild. Oysters, clams and scallops are harvested via dredge, although different dredge configurations are required for the different species. Cockles are harvested via hand as pump scoop dredges are not allowed in the area.

4.3 SEASONALITY OF HARVEST, CONSERVATION CONTROLS AND DEVELOPMENT POTENTIAL

The harvest of oysters is only allowed from 1st November through to the end of February. The fishery is also subject to other byelaws including a minimum landing size of 70mm, and restrictions on the width of dredge that can be used. Oyster dredging can only be undertaken between 08:00 and 16:00. 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. A decision on this will be made by committee shortly, and any closure would be reviewed on an annual basis. The prospects for this fishery are poor for several years at least given the current stock status and lack of successful spatfall in recent years.

There are no closed seasons for clams, although most activity in this fishery is during the winter months. Minimum landing sizes apply to Manila clams (35mm), hard clams (63mm), and palourdes (40mm). Clam dredging can only be undertaken between 08:00 and 16:00 and there are some restrictions on dredge design. The prospects for this fishery are uncertain.

The harvest of cockles is closed from February to April inclusive, and a minimum landing size of 23.8mm applies. As pump scoop dredges are not permitted here cockle harvesting has to be done by hand so commercial interest is likely to be much lower than it was before 2004 when the technique was banned. There is no closed season for razors, and the national minimum landing size of 100mm applies. It is uncertain if and when there will be renewed commercial interest in either cockles or razors.

There is no closed season for scallop dredging, although activity in this fishery has peaked during the winter months. Scallop dredging can only be undertaken between 07:00 and 19:00, and there are some restrictions on dredge configuration. A minimum landing size of 110mm applies. This fishery has seen a steady increase in effort since it started three years ago suggesting it has been worthwhile up to now. The future prospects will depend largely on whether stocks can sustain current and future levels of exploitation.

Several areas are subject to a voluntary dredging ban to protect seagrass beds (Jury, 2013). As this voluntary ban has not been universally adhered to, the IFCA are likely to prohibit all towed gear within these areas. The IFCA also intends to prohibit other activities likely to damage seagrass, including digging of shellfish within these areas. Both these byelaws are likely to be in force by the end of 2013. The seagrass beds coincide with the clam/cockle bed off Chilling, the entirety of Kings Quay Beach, and some of the beach at Ryde (Figure 4.1) so if these byelaws are adopted these areas would no longer be legally exploitable.

4.5 Hygiene Classification

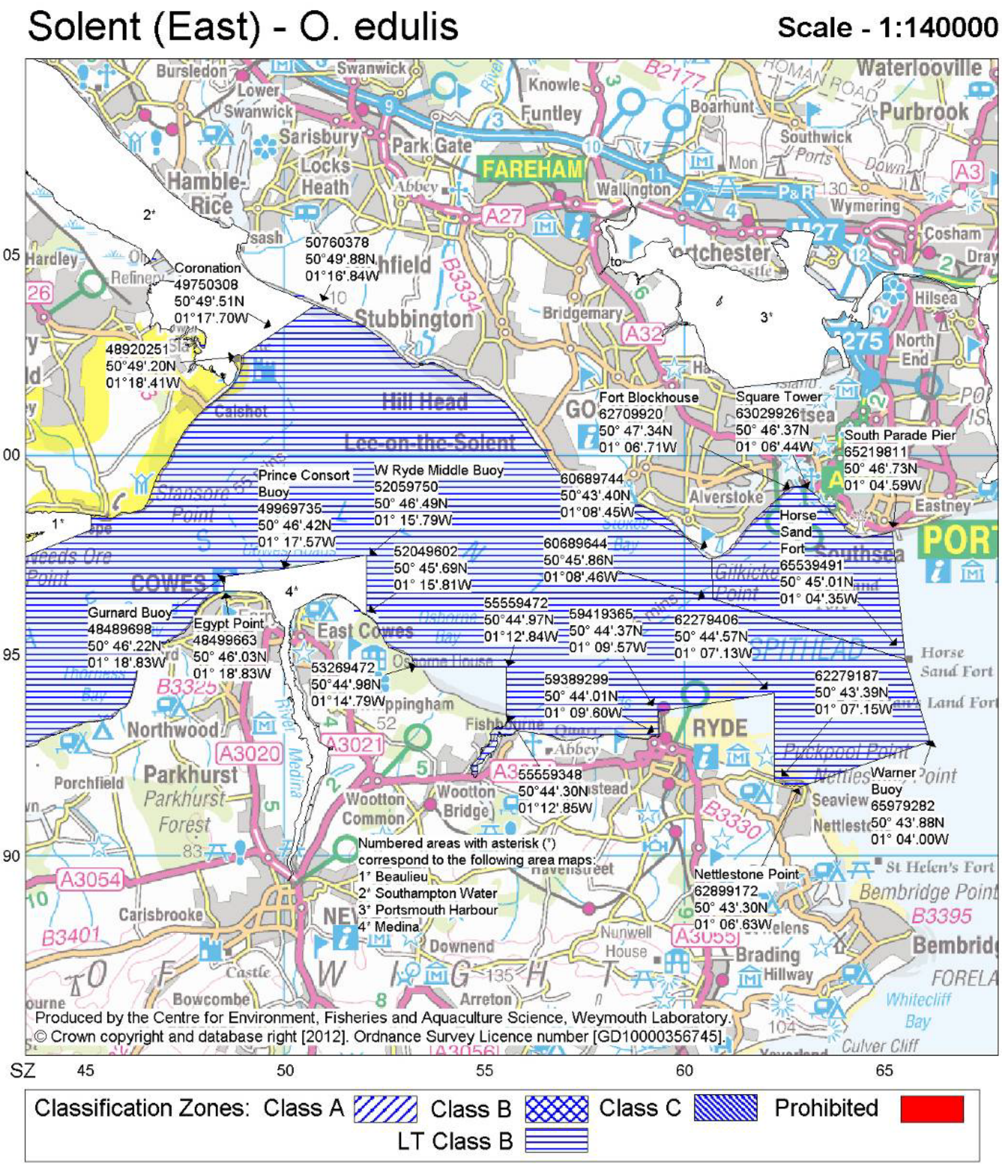
Table 4.1 Classification history for the Solent, 2003 onwards

Area	Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Ryde Middle Bank	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Spit Bank	Nat. oyster	B	B	B	B	B	C	B	B-LT	B-LT	B-LT
Stokes Bay	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Stokes Bay	Hard clams	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
The Butts	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
The Butts	Hard clams	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Lee on Solent	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Lee on Solent	Hard clams	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	-	-
Lee on Solent	Cockles	-	B	B	B	C	C	C	-	-	-
Hill Head	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Bramble Bank	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Stanswood Bay	Nat. oyster	B	B	B-LT	A	B	B	B	B-LT	B-LT	B-LT
Calshot	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Lepe	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
East Sowley	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Yarmouth West	Nat. oyster	-	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Yarmouth East	Nat. oyster	-	A	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Yarmouth	Nat. oyster	B	-	-	-	-	-	-	-	-	-
Newtown Bank	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Thorness	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Osborne Bay	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Peel Bank	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Mother bank	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
S W of Gilkicker	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Lymington Bank	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Sowley	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Pennington Bank	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
East Ryde Middle	Nat. oyster	B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
West Ryde Middle	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Kings Quay	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Saltmead Ledge	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Ryde Sands	Cockles	-	-	C	C	C	C	C	C	-	-
Ryde	Nat. oyster	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Brownwich Reach	Cockles	-	B	B	B	C	C	C	-	-	-
Hillhead Haven	Cockles	-	B	B	B	C	C	C	-	-	-
Hill Head	Hard clams	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	-	-
Kings Quay Beach	All species	-	-	-	-	-	-	P	P	-	-

LT denotes long term classification

All oyster beds within the Solent are currently classified as a long term B. The current classified area does not include all of the Warner bed or the Osbourne bed, which were fished in 2012/13. Stokes Bay, Lee on Solent and Hill Head have all been classified for hard clams in recent years, although only Stokes Bay is currently classified. Clam classifications have been awarded on the basis of native oyster sample results, and the clams themselves have never been sampled. No classification has ever been issued for Manila clams, which are the main clam species harvested. The current hard clam classification does not coincide with the area off Chilling which is fished for Manila clams. Cockle classifications have been issued at Lee on Solent, Ryde Sands, Brownwich Reach and Hillhead Haven. The most recent classifications for all these areas have been Cs. No areas are currently classified for cockles. There have been no classifications for scallops. Kings Quay

Beach was prohibited on the basis of cockle and razor sampling results, but this prohibited classification no longer applies.



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

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

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

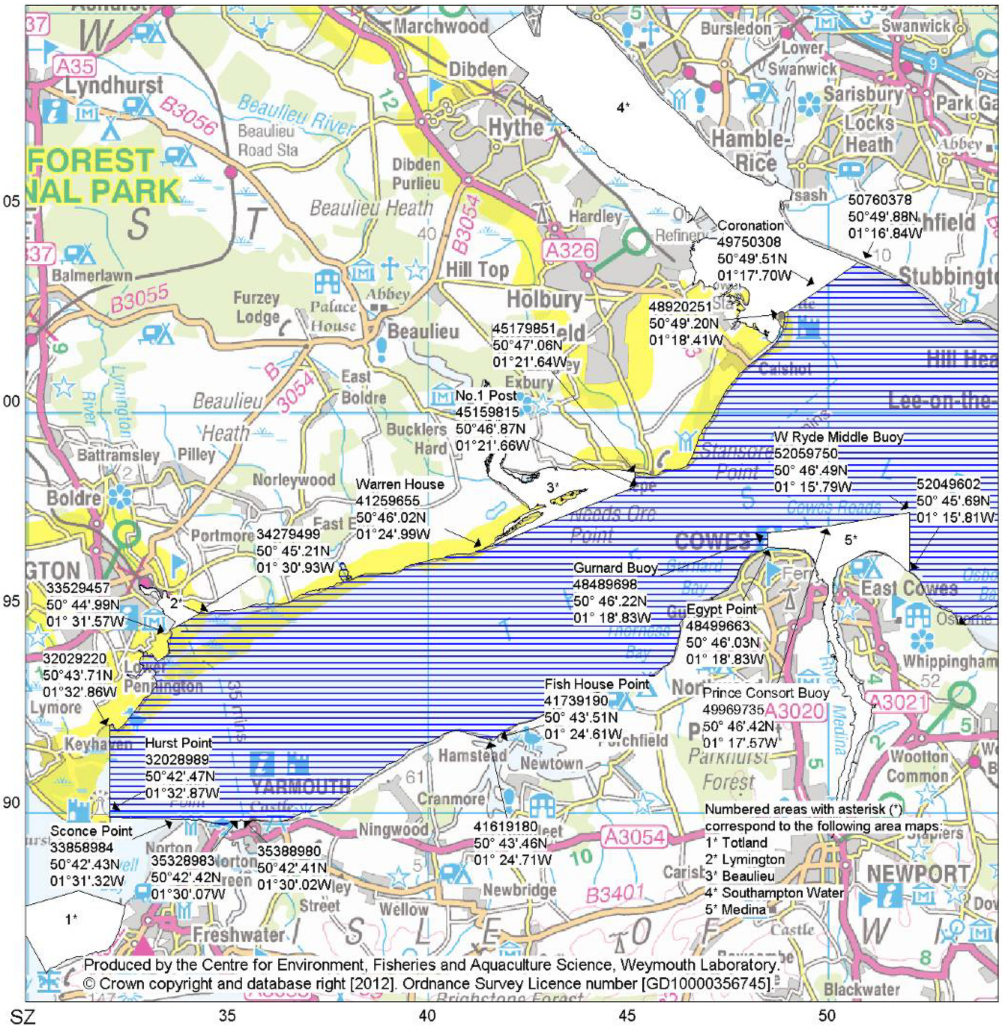
N.B. Lat/Longs quoted are WGS84
Separate map available for M. mercenaria at Solent (East)

Food Authorities: Fareham Borough Council, Gosport Borough Council, Isle of Wight Council, Portsmouth Port Health Authority, Southampton Port Health Authority

Figure 4.3 Current native oyster classifications (Solent East)

Solent (West) - O. edulis

Scale - 1:140000



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

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

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

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

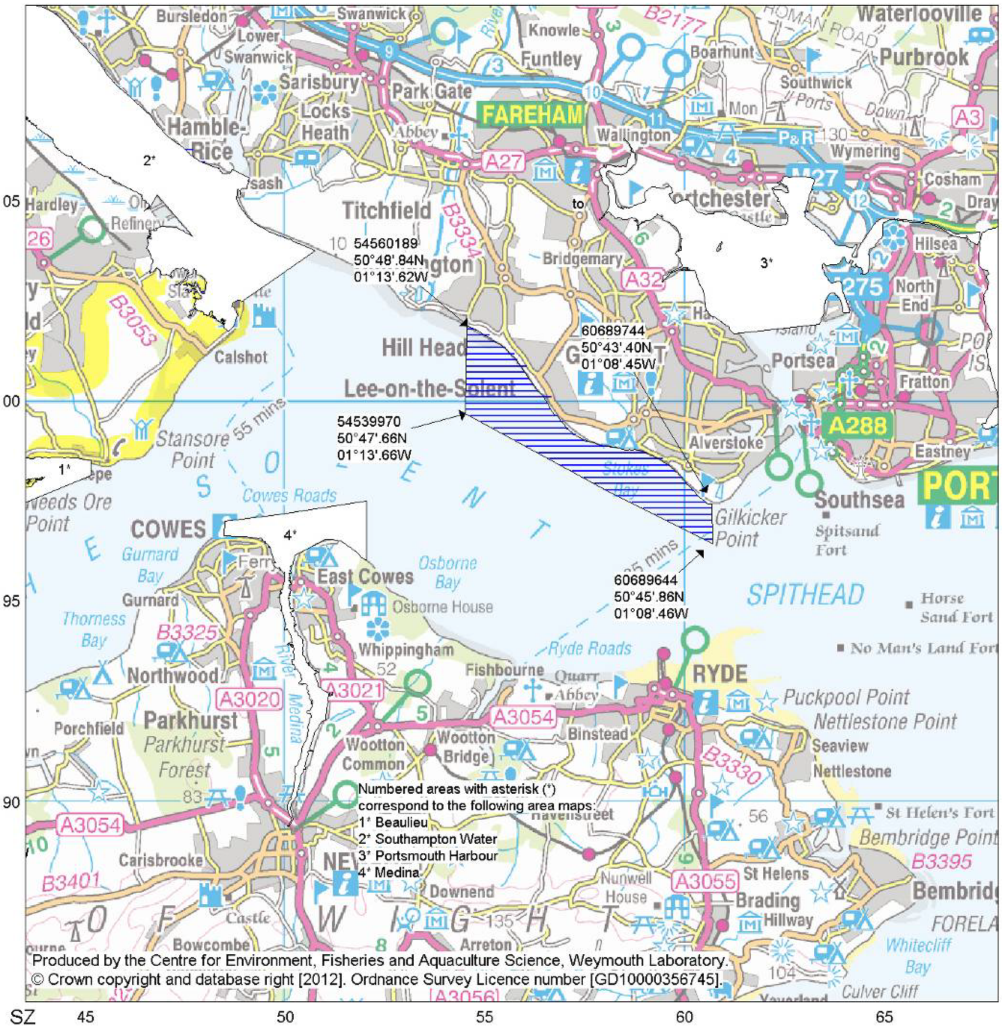
N.B. Lat/Longs quoted are WGS84
Separate maps available for C. edule and Clams (M. mercenaria) at Solent (West)

Food Authorities: Isle of Wight Council
New Forest District Council
Southampton Port Health Authority

Figure 4.4 Current native oyster classifications (Solent West)

Solent (East) - M. mercenaria

Scale - 1:140000



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

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

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

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

N.B. Lat/Longs quoted are WGS84
Separate map available for O. edulis at Solent (East)

Food Authorities: Fareham Borough Council, Gosport Borough Council, Isle of Wight Council, Portsmouth Port Health Authority, Southampton Port Health Authority

Figure 4.5 Current hard clam classifications

Table 4.2 Criteria for classification of bivalve mollusc production areas.

Class	Microbiological standard[1]	Post-harvest treatment required
A[2]	Live bivalve molluscs from these areas must not exceed 230 Most Probable Number (MPN) of *E. coli*/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

AIM

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

SHELLFISHERIES

Until recently the Solent supported a major native oyster dredge fishery spread across many discrete beds within a wide geographical area. At its peak in the 1979/80 season 840 tonnes of native oysters were landed to Solent ports. Stocks started to decline in the western Solent during the 1980s but continued to spread in the eastern Solent. Since 2006 stocks in the eastern Solent have been declining sharply. Now, most of the former oyster beds in the western Solent only support the occasional specimen, and commercially exploitable densities are limited to the eastern Solent. This has been reflected in recent exploitation patterns. Last season (2012/13) only 15-20 boats dredged for oysters within the Solent production area, and the majority left the fishery by mid December. Areas fished were primarily Ryde Middle, Sturbridge and Warner, with some activity at Chilling, Lee on Solent, North Channel, Portsmouth Spit and Osbourne Bay. There has not been a significant spatfall since 2006, and until one occurs the prospects for the fishery are very poor.

The current stock status has made the collection of samples increasingly difficult at some RMPs. There is likely to be scope for declassifying some areas where stocks are particularly barren and are no longer exploited, although this will have to be done with the agreement of the fishing community. None of the oyster beds in the western Solent was subject to commercial activity in the 2012/13 season.

Currently the oyster fishing season runs from November through to February and the fishery within the Solent is a public fishery managed via local byelaws. The IFCA are likely to temporarily close the oyster fishery within the Solent for the 2013/14 season, although this has yet to be decided by committee at their June meeting. A closure would then be reviewed on an annual basis. Such a closure would not apply to the fishery order at Stanswood. If a closure is announced sampling frequency may be reduced to quarterly and the area temporarily declassified. Under this status, the classification can be reinstated immediately upon resumption of monthly sampling. If no closure is announced and the fishery requires continued classification there is still some scope to reduce sampling frequency as the fishery is a seasonal one. Monthly sampling should be continued but the first two months of the closed season (March and April) need not be sampled assuming a full set of 10 samples are taken throughout the remaining months. The preferred option from a public health perspective however would be for monthly sampling to continue throughout the year. Current classification boundaries do not include the entirety of the Warner or Osbourne beds, both of which saw some activity in 2012/13.

Some species of clams are commercially exploited within the Solent via either dredge or hand digging. The commercial clam populations lie on the north east shore of the Solent at Chilling. The vast majority of catches are of Manila clams, with a small bycatch of American hard clams, palourdes and possibly other species. This area is not currently classified for any species of clam, although there is an area classified for hard clams to the south east. The hard clam classification is currently based on native oyster monitoring results, and clams have never been sampled. Hard clams accumulate *E. coli* to broadly similar levels as oysters, so this may be acceptable in some instances. For classification purposes, both Manila clams and native clams are treated as the same species (referred to as *Tapes* spp.). Manila clams accumulate *E. coli* to higher levels than native oysters so oyster monitoring would not be an acceptable surrogate for *Tapes* spp. (Younger & Reese, 2011). All clam species require a year round classification as there is no formal closed season.

A significant scallop dredge fishery has arisen over the last three winters. Scallop dredge fisheries are not usually classified due to their typically offshore locations. Scallops from unclassified areas may be marketed providing the controls specified in Regulation 853/2004 (testing by the food business at fish auction, dispatch or processing establishment) are carried out to ensure that the end product standards are met. This however is a classified area, so the scallops should be given a classification. Ideally this should be based on scallop sampling but may potentially be based on oyster sampling results, if a preliminary classification is required immediately. There is however some uncertainty on the relative *E. coli* accumulation of these two species. The current B classification for native oysters, if applied to scallops, would mean that they will require depuration or heat treatment prior to sale.

Historically, there have been some areas of cockles within the eastern Solent which were of commercial interest at Ryde, Kings Quay Beach and Chilling. These are only subject to casual gathering at present. Erosion of sands has removed the majority of razor stocks at Ryde, but there may be some at Kings Quay Beach.

There are areas of seagrass within the Solent within which the IFCA are likely ban both dredging and shellfish digging via new byelaws. It is envisaged that these byelaws will be in place by 2013. If and when these byelaws come into force it may be prudent to declassify these areas to avoid any potential confusion regarding the legality of harvesting shellfish within them. They coincide with intertidal shellfish beds at Chilling, Ryde and Kings Quay Beach.

POLLUTION SOURCES

FRESHWATER INPUTS

The catchment area draining into the Solent is around 3,050 km^2. The largest rivers within this area are the Test and Itchen, both of which drain to the upper reaches of Southampton Water. The Hamble also drains to Southampton Water. Flow gauging records indicate that the majority of freshwater inputs in terms of volume are to Southampton Water. There are also several significant freshwater inputs direct to the Solent, including the Lymington and Beaulieu rivers in the New Forest, the River Meon which discharges to the north east Solent, and the River Medina and the Eastern Yar on the Isle of Wight. In addition to these there are numerous smaller watercourses discharging either direct to the Solent or to estuaries which discharge to the Solent. These rivers will all receive microbiological pollution from point and diffuse sources such as STW discharges and urban and agricultural runoff. They are therefore a potentially significant source of microbiological contamination for the shellfisheries in the area.

The Rivers Test, Itchen and Meon originate in the northern reaches of the catchment where the dominant bedrock is chalk so a significant proportion of flows originate from groundwaters. These southern parts of the Test and Itchen catchments have less permeable bedrock so the lower reaches of these rivers receive more land runoff. The other rivers and the smaller watercourses drain areas of less permeable geology so will have higher runoff rates and more variable flows. The patterns of impacts from these rivers and streams within the Solent will be heavily influenced by the shape and size of any estuaries they discharge through. In general, smaller watercourses will tend to drain directly to the Solent, whereas larger ones will have more in the way of an estuary. Defined estuaries will offer some scope for dilution and mixing as well as limiting the flow of contamination into the Solent to the ebb tide. The characteristics of these larger estuaries are examined in more detail under the hydrography heading.

In general, flows were highest in the colder months. Flows were highly variable on a day to day basis in some of the water courses, particularly those with lower average flow rates. Flows on the chalk streams (Test, Itchen and Meon) were less variable reflecting the steady contribution from groundwaters. During the shoreline survey watercourses which could be safely accessed were measured and sampled allowing spot estimates of the *E. coli* loading they were generating to be made. This was not a comprehensive survey and a significant number of watercourses, including the larger rivers, were not surveyed in this manner for various reasons. There were several small streams which discharged from the north shore of the Isle of Wight. The highest measured loading was from a small stream at Cowes (2.3×10^{13} cfu/day). A larger watercourse just east of Cowes also carried a significant loading (3.4×10^{12} cfu/day). Another small stream at Thorness Bay also generated a loading of 3.4×10^{12} cfu/day and observations suggest it was subject to contamination from manure at the time. There were no significant minor streams discharging from the New Forest. The Alver River on the eastern end of the mainland stretch of the Solent contributed approximately 4.9×10^{12} *E. coli* per day and is therefore a potentially significant source of contamination.

HUMAN POPULATION

Total resident population within the Solent catchment area was about 1,513,000 at the time of the last census for which data was available at the time of writing. Of these just under 140,000 reside on the Isle of Wight, so the majority of sewage will be generated by the mainland. Population densities were generally highest adjacent to the coast. The main conurbations on the mainland are Southampton and Portsmouth, although there are some large towns such as Winchester and Andover further inland. The more inland parts of the mainland catchment are generally more rural, and the New Forest which borders the north east coast of the Solent is also relatively sparsely populated. On the Isle of Wight population densities are highest along the north coast. Impacts from sewage will depend on the nature and locations of discharges associated with these settlements.

The area has many tourist attractions and receives significant influxes of visitors. Population increases are especially significant for the Isle of Wight, where population almost doubles at the height of the summer festival season. Therefore sewage works will be serving larger populations during the summer holiday season.

SEWAGE DISCHARGES

There are three major sewage treatments works discharging direct to the Solent (Pennington, Peel Common and Budds Farm STWs) all of which provided secondary treatment until March 2013, when UV disinfection was added to all three. Estimates of the bacterial loading they generated before disinfection was added were 5.40×10^{13}, 1.97×10^{14} and 3.59×10^{14} faecal coliforms per day respectively. It is anticipated that the bacterial loadings they generate will have decreased by about 3 orders of magnitude after the addition of UV treatment, greatly reducing their impacts. They discharge via long sea outfalls to depths of about 2m (Pennington) 16m (Peel Common) and 20m (Budds Farm) below chart datum. The spatial profile of their impacts will be largely determined by water circulation patterns. There is also a small primary works at Thorns Beach which discharges direct to the Solent, although this only generates an estimated loading of 8.30×10^{10} faecal coliforms per day so its impacts will be minor and localised.

There are also a significant number of large (secondary treated) discharges to Southampton Water or the lower reaches of rivers discharging to this water body (Test, Itchen and Hamble), so the ebb plume from here is likely to be a further significant contaminating influence. Additionally, most major watercourses such as the Lymington River and the Beaulieu River receive some sewage effluent and so the plumes emanating from these river mouths also represent a source of sewage related contamination. Effluent from the main settlements on the Isle of Wight is treated at Sandown and discharged via a long sea outfall off the south east coast of the island, and so should not influence water quality within the Solent.

As well as the continuous sewage works, there are a large number of intermittent overflow discharges associated with the sewerage networks. Spills will mainly be associated with wet weather events, particularly within the sewerage networks which collect larger amounts of surface water, and some catchments and individual outfalls may have a greater tendency to spill than others. Of the 85 intermittent discharges lying within 2km of the Solent production area the main clusters are at the towns of Norton, Cowes, Ryde and Gosport. Spill records were available for 55 of these for the period January 2009 to March 2012 in the form of event start and end times, but with no indication of volumes spilled. No spills were recorded at 19 of the monitored outfalls. For those which did record spills, 15 spilled for less than 0.1% of this period, 12 spilled for between 0.1% and 1% of the time, four spilled for between 1% and 5% of the time, and 5 spilled for more than 5% of the time. The main spillers were all located on the north shore of the Isle of Wight (Gurnard PS (18.4%), Egypt Point PS (10.2%), Ryde (Appley Park) Headworks PS, Woodvale/Gurnard Headworks PS (7.4%) and Cowes (Springhill) Headworks WPS (6.3%)). For the other intermittent outfalls it is difficult to make any meaningful assessment of their relative significance aside from noting their locations and their potential to deliver large bacterial loadings. There are many further intermittent discharges outside of the 2km buffer set around the classified fishery, particularly around Southampton Water.

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 monitoring from which the classification is derived, as they only operate occasionally. Thus when they do have a significant spill, heavily contaminated shellfish may be harvested under a better classification than the levels of *E. coli* within them may merit. A reactive system alerting relevant parties to spill events in real time may therefore convey better public health protection.

Although the vast majority of sewage generated in the area is collected treated and disposed of by water company sewerage infrastructure, there are over 200 privately operated sewage discharges within 2km of the Solent production area. The majority of these are small, serving one or a small number of properties and discharging less than 1m^3/day. About 40% discharge to soakaway (and should have little effect on coastal waters) and about 60% discharge to either watercourses or coastal waters. Where specified, the treatment is usually via septic tank or package plant. Only 12 of these are consented to discharge more than 5m^3 per day. The only one of potentially major significance to shellfisheries in the Solent is the Thorness Bay Holiday Park, which is consented to discharge up to 568 m^3 per day just below the low tide mark in Thorness Bay. It is likely that flows from here vary with season, peaking during the summer holidays.

AGRICULTURE

Most agricultural land within the hydrological catchment of the Solent is used for arable farming, and organic fertilisers may be applied to these areas periodically, with timing depending on crop cycles. There are some areas of pasture, particularly on the Isle of Wight and in the lower parts of the catchment on the mainland onto which grazing animals will deposit faeces directly. There are significant numbers of grazing animals within the catchment with almost 70,000 cattle and over 100,000 sheep. The Isle of Wight supports the highest densities of both, so land runoff from here is likely to be most heavily impacted by grazers, although all major watercourses may be affected to some extent. Little was seen in the way of livestock during the shoreline survey. A small stream at Thorness Bay had a strong manure odour and contained very high levels of *E. coli* suggesting significant livestock contamination of this watercourse at the time.

The primary mechanism for mobilisation of faecal matter deposited or spread on farmland to coastal waters is via land runoff, so fluxes of livestock related contamination into the estuary will be highly rainfall dependent. Rainfall and river flows are generally highest during the winter months, but high rainfall events may occur at any time of the year. Peak concentrations of faecal indicator bacteria in watercourses are likely to arise when heavy rain follows a significant dry period (the 'first flush'). Numbers of sheep and cattle will increase in the spring with the birth of lambs and calves, and decrease in the autumn when animals are sent to market. The seasonal pattern of application of manures and slurries is uncertain. Cattle may be housed indoors in winter so applications of slurry to pastures in these farms may be more likely during the winter and spring.

BOATS

The Solent is an area which sees very heavy boat traffic from a large range of vessels, from large cargo vessels through to small pleasure craft. There are three major commercial ports in the vicinity (Southampton, Portsmouth and Cowes), a fishing fleet of around 140 vessels, several busy ferry routes and numerous marinas and mooring sites for pleasure craft such as yachts and cabin cruisers. A large proportion of traffic is to and from Southampton Water, and the eastern Solent offers a much easier passage to here than the western Solent so larger vessels approach from the east. Portsmouth Harbour is accessed via a channel at the very eastern end of the survey area.

Merchant shipping, which include ferries and cruise liners, are not permitted to make overboard discharges to inshore waters so should be of no impact. Smaller pleasure vessels such as sailing dinghies will not have onboard toilets so are very unlikely to make overboard discharges. Of the vessels using the Solent, private vessels of sufficient size to have onboard toilets are thought to be most likely to make overboard discharges. This will include most yachts, cabin cruisers and the larger fishing vessels. The moorings and marinas are generally located in the more sheltered areas, typically within enclosed estuaries adjacent to the Solent. Areas of moorings are present within the Medina, Lymington River, Beaulieu River, Yarmouth, Keyhaven, Wootton Creek and Newtown River, as well as Southampton Water and Portsmouth Harbour. There are marinas within the Medina, Lymington River, Beaulieu River, Yarmouth estuary, Southampton Water and at Ryde. Sewage pumpout facilities are available at a small proportion of these marinas.

Boats in marinas may be less inclined to make overboard discharges as it is somewhat antisocial and onshore facilities are easily accessed. Those in occupation on moorings, or those in transit through the estuary may be more likely to discharge. On this basis Southampton Water, Portsmouth Harbour, Medina, Lymington River, Beaulieu River, Yarmouth, Keyhaven, Wootton Creek and Newtown River are most at risk, and the ebb plumes from these estuaries may potentially contain significant amounts of contamination of boat origin at times. The deeper areas and buoyed navigation routes will also be at risk from discharges made on passage. Peak pleasure craft activity is anticipated during the summer, particularly during regattas such as Cowes Week so associated impacts are likely to follow this seasonal pattern. However, it is difficult to be more specific without any firm information about the locations, timings and volumes of such discharges. Overboard discharges made by vessels on passage may occur almost anywhere and at any time so will not influence the sampling plan. Those made by moored boats will be best captured by RMPs within the ebb plumes from the estuaries where moorings are located.

WILDLIFE

The Solent and adjoining estuaries contain a large diversity of habitats including sand and gravel banks, intertidal mudflats, saline lagoons, shingle beaches, reedbeds and grazing marsh. These attract large numbers of overwintering waterbirds (wildfowl and waders) which are likely to be the most significant wildlife aggregations in terms of their impacts on shellfish hygiene. Average total waterbird counts over the five winters up to 2010/11 were 15,534 in the north west Solent, 12,810 in Portsmouth Harbour and 12,015 in Southampton Water. The Medina Estuary supported an average total count of 8,334 birds over the winters 2008/09 and 2009/10. Other estuaries and areas of Solent shoreline were not subject to bird counts but will support significant populations where there are suitable habitats.

Most of these migrate elsewhere to breed. Smaller numbers of seabirds (gulls etc) are present in the area throughout the year. Therefore some impacts from birds may be anticipated, mainly during the winter months. These may be through direct deposition on intertidal areas or via land runoff. The adjacent estuaries are likely to be preferred foraging areas, although the intertidal areas of the Solent itself will also be used. Their presence is more of a concern for intertidal shellfisheries rather than subtidal ones. Their inputs may be considered as diffuse, so whilst they may cause increases of indicator organisms within shellfish, birds do not directly influence the sampling plan aside from perhaps a tendency for greater impacts within the adjacent estuaries.

There is a small colony of harbour seals (~25 animals) and the occasional grey seal within the Solent. During the moulting and pupping season (June to August for harbour seals) they tend to spend more time at haulout sites in Langstone and Chichester Harbours and less time in the Solent. Bottlenose dolphins and harbour porpoises have also been sighted within the Solent but their numbers are likely to be small. Marine mammals will range widely throughout the area, so any impacts (outside of seal haulout sites) will be unpredictable spatially and temporally, and very minor given their small numbers, so will have no influence on the sampling plan.

Domestic animals

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

Summary of Pollution Sources

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

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

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

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

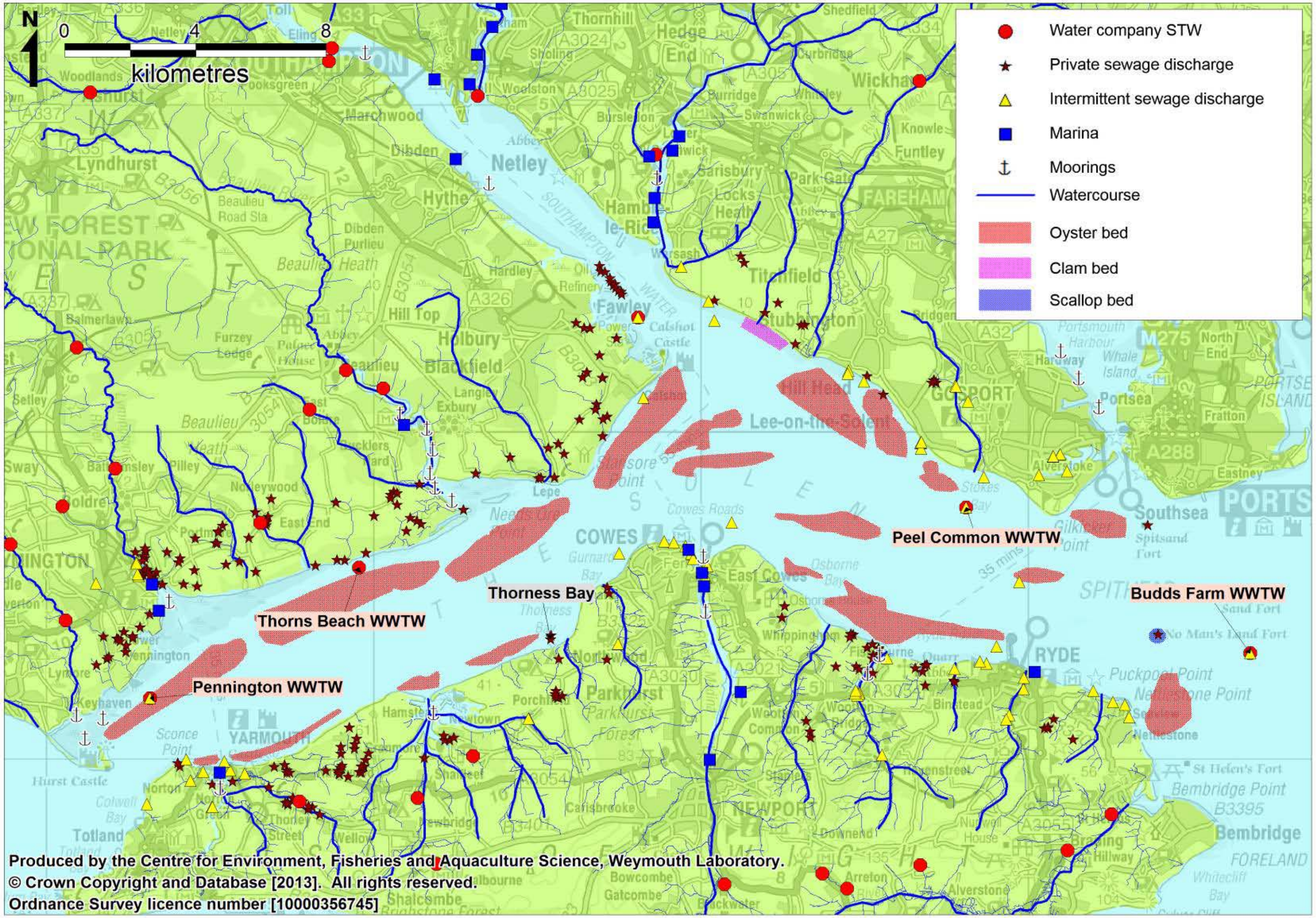


Figure 5.1 Significant sources of microbiological pollution to the Solent.

HYDROGRAPHY

The Solent is a large, semi enclosed water body which lies between the Isle of Wight and the south coast of England, with openings to the English Channel at either end. It is approximately 32km in length about 3-5km in width, with a wide central channel generally between 12 and 25m in depth flanked by gently sloping subtidal and intertidal areas of varying width. The western entrance is relatively narrow and deep compared to the rest of the Solent and the eastern entrance. Along the north western shore the intertidal gradually slopes south towards the main channel. The south western shore displays a steeper gradient, with a smaller intertidal area. The north east shore is gently sloping at the mouth of Southampton Water but becomes progressively steeper eastwards. The south east shore has a gentle gradient, with a large intertidal area off Ryde.

There are seven defined estuaries of varying shapes and sizes which drain directly into the survey area (Southampton Water, Beaulieu River, Newtown Creek, Lymington, Medina, Western Yar and Wootton Creek). As these estuaries are enclosed and they receive contamination from various sources, levels of faecal indicator bacteria within them are likely to be higher than within the Solent as a whole. Their shape and size will influence the extent to which these indicators will be diluted and die off before being carried out into the Solent. All are of sufficient size relative to river inputs that they will only discharge to the Solent as the tide ebbs. The River Meon does not have a significant estuary, but discharges via a dammed wetland directly into the Solent so will impact both on the flood and ebb tides.

Of the seven estuaries, Southampton Water, which extends in a north westerly direction from the central Solent, is by far the largest and also receives much more than the other estuaries in terms of sewage and riverine inputs. The ebb plume from this estuary is therefore likely to have a significant and wide ranging influence, although there is high potential for dilution of contamination before it reaches the Solent. The main channel from this estuary is the Thorn Channel, which runs in a south westerly direction off Calshot, and is maintained by dredging. The other estuaries are much smaller but do receive contamination from a mix of sources such as sewage discharges, land runoff and diffuse sources such as boat traffic and wildlife. All are considered well mixed under normal (low river flow) conditions, indicating that the freshwater influence in their ebb plume will be low, although under high river flow conditions there may be a plume of less saline water originating from them, particularly in the case of the Beaulieu and Lymington. Some vertical stratification was observed within the mouth of the Beaulieu during the shoreline survey.

Currents in coastal waters are predominantly driven by a combination of tide, wind and density effects. Tidal amplitude is relatively large, and tidal streams dominate patterns of water circulation in the area. The Solent has a complex asymmetrical tidal regime, with tidal stand still and double high waters experienced at several locations. Tidal amplitude on spring tides decreases towards the western end, from 3.8m at Ryde to 2.0m at Hurst Point, and is about half these sizes on neaps.

Within the English Channel, tidal streams are bi-directional, flooding in an easterly direction, with the reverse occurring on the ebb. The same pattern occurs within the

Solent, with tidal streams running parallel to the shores between the Isle of Wight and the mainland. In the central Solent the tidal stream splits, with the largest proportion flooding south-east towards the eastern entrance and a small proportion flooding north into Southampton Water through the Thorn channel. Tidal flows are also redirected around the raised Bramble sand bank located on the southeast of the mouth of Southampton water and rejoin with the main eastern Solent Channel. Contamination from shoreline sources will therefore tend to travel along the shore to which it is discharged, becoming progressively more diluted with distance. On an ebb tide plumes from the adjoining estuaries will be carried in a westerly direction.

Tides are ebb dominant, with a shorter duration and faster moving ebb tide. Tidal stream velocities are higher in the western Solent than in the eastern Solent. Peak current velocities of 2.26m/s on spring tides arise in the western entrance. Estimated tidal excursions are in the order of 21km on spring tides and 10km on neap tides in the western Solent, and around 14km on spring tides and 7km on neap tides in the eastern Solent. Therefore sources in the western Solent will tend to have wider ranging, but slightly less acute impacts. Currents are considerably stronger in the deeper waters of the central channel compared to the nearshore and intertidal areas, so shoreline sources will not have such wide ranging impacts as those in deeper water, but will create more acute hotspots of contamination.

Freshwater inputs are unlikely to modify circulation via density effects outside of the estuaries. Salinity measurements taken repeatedly at numerous stations within the Solent indicate average surface salinities approaching that of full strength seawater throughout. Very slightly lower average salinities were recorded at stations located in the mouth of Southampton Water, suggesting a slightly higher freshwater influence here. One density effect of potential significance is that sewage effluent discharged from long sea outfalls in deeper water, such as the Budds Farm outfall will be less dense than the surrounding seawater and so will float up and away from benthic shellfish stocks. This will be more of a consideration for Budds Farm and Peel Common STWs as they discharge to water depths of over 15m. The Pennington outfall lies in only 2m of water.

Strong winds will modify surface currents by driving surface currents, which will in turn create return currents which may travel lower in the water column or along sheltered margins. As such winds may significantly modify the shape of buoyant plumes from the major sewage outfalls at times. The prevailing south-westerly winds will tend to push surface water in a north-easterly direction, towards the western entrance of the Solent. Exact effects are dependent on the wind speed and direction as well as state of the tide and other environmental variables so a great range of scenarios may arise. Strong winds may also create wave action, which may resuspend contamination from intertidal sediments. Energetic wave action is not a feature of the Solent however due to the limited fetch.

SUMMARY OF EXISTING MICROBIOLOGICAL DATA

The Solent has been subject to considerable microbiological monitoring over recent years, deriving from Bathing Waters and Shellfish Waters monitoring programmes as well as shellfish flesh monitoring for hygiene classification purposes. Figure 5.2 shows the locations of the seawater sampling points referred to in this assessment.

The results of samples taken since 2003 are considered here. All sample results considered in this report pre-date the UV upgrades to the three main sewage discharges to the Solent which were completed in March 2013. Therefore, the historical microbiological monitoring results should be treated with some caution, particularly at monitoring points in close proximity to their outfalls.

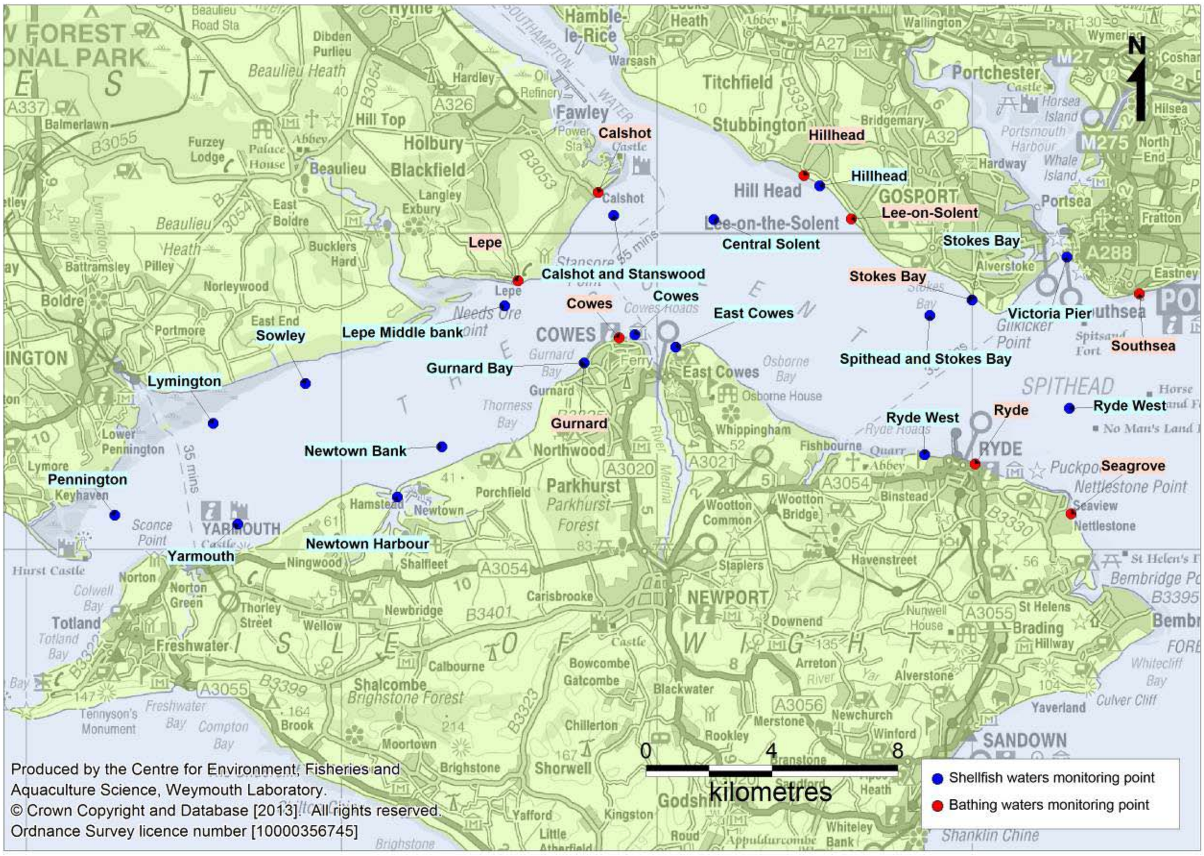


Figure 5.2. Location of seawater sampling sites

Ten sites were sampled under the Bathing Waters monitoring programme where around 20 samples were taken from the intertidal each bathing season (May-September) and enumerated for faecal coliforms. Due to changes in the analyses of bathing water quality by the Environment Agency from 2012, only data produced up to the end of 2011 was used in these analyses.

Levels of contamination were broadly similar at all sites except Southsea, between Portsmouth and Langstone Harbours, where they were significantly higher than all other sites. Results at Calshot and Lepe were very similar, and these were the only two sites where results of over 1000 faecal coliforms/100ml were not recorded. Results were significantly higher at Hill Head compared to Lee on Solent. There were fewer very low results at Gurnard, Cowes and Ryde, on the north shore of the Isle of Wight, although there were no significant differences between average results across all four Isle of Wight sites.

Results at all sites showed correlations with tidal state on both tidal cycles, with the exception of Stokes Bay, where the influence of the spring/neap cycle was not quite statistically significant. At all of the bathing water sites except Southsea, some tendency for higher levels of faecal coliforms around or just after high tide was apparent. The reasons for this are unclear. At Southsea, faecal coliform levels were highest at around low water and on the early flood tide suggesting contamination from the adjacent harbours may be of significance. Lepe, Calshot, Lee-on-Solent and Seagrove showed a tendency for higher faecal coliform results around spring tides. Southsea had higher results whilst tide size decreased from spring to neap tide. No obvious patterns across the spring neap tidal cycle were apparent at the other sites when the data was plotted.

All bathing waters sites except for Southsea were affected to some degree by rainfall. Most affected sites responded within the first day after a rainfall event, but were no longer affected after 3 to 5 days. Cowes on the other hand continued to be affected by rainfall for at least a week after rain.

Taken together this data indicates that levels of contamination are broadly similar throughout the sites, and that all respond in a similar manner to rainfall. The exception to this is Southsea, where results were significantly higher and no influence of rainfall was detected. This suggests a different profile of contaminating sources is impacting here.

Twelve sites were sampled under the Shellfish Waters monitoring programme, under which water samples were taken and tested for faecal coliforms on a quarterly basis (Figure 5.2). Across these, “Spithead and Stokes Bay” had significantly greater levels of faecal coliforms than all other sites except Calshot/Stanswood, Yarmouth, Newtown Harbour and Ryde. Additonally Ryde had significantly higher level of faecal coliforms than Lepe Middle Bank. Around half of these sites showed a negative correlation between salinity and faecal coliform concentrations, with the stronger correlations apparent at Calshot/Stanswood, Newtown Harbour, Cowes and Central Solent. Most sites showed some influence of rainfall although this was not particularly strong or consistent.

Since 2003 a total of 35 RMPs have been sampled and tested for *E. coli* levels in shellfish flesh for hygiene classification purposes. Figure 5.3 shows the locations of these.

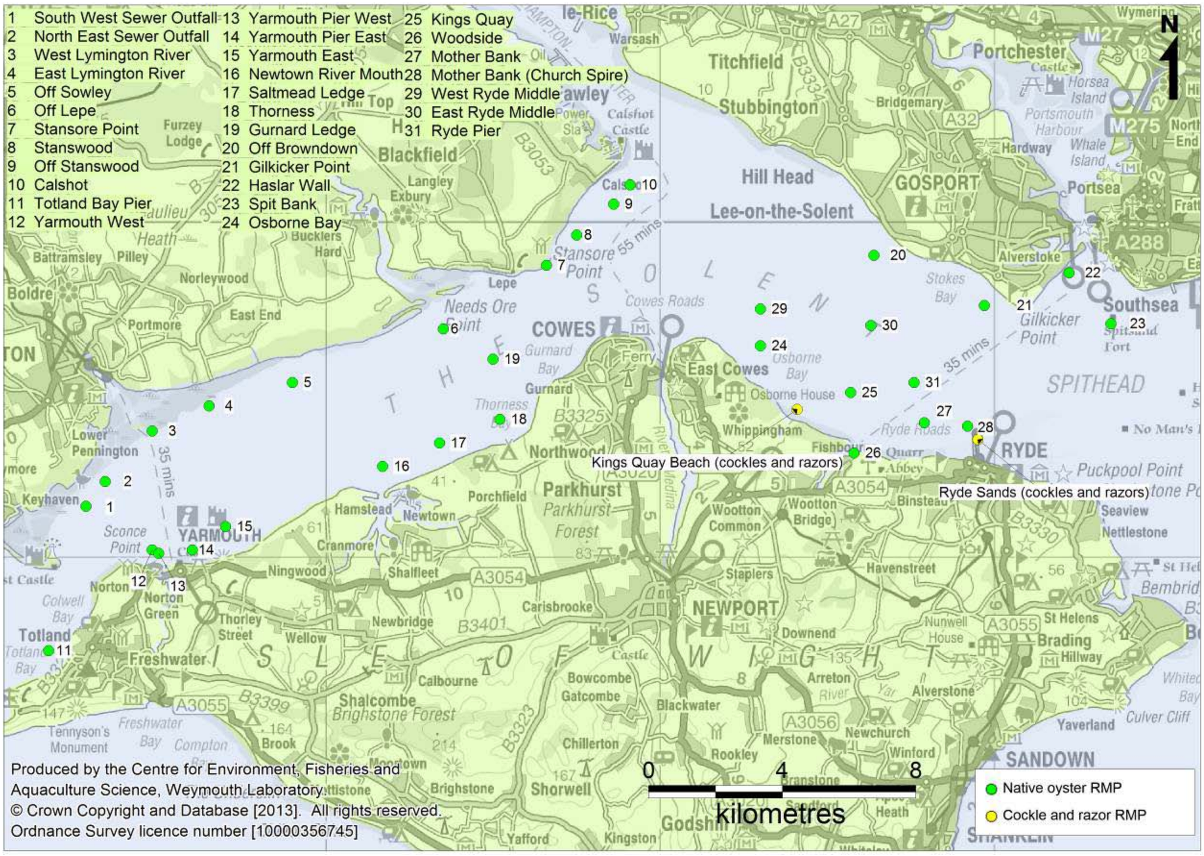


Figure 5.3. Location of shellfish sampling sites

Of these the vast majority (31) were native oyster RMPs. Compliance with class B requirements was apparent at all, but some spatial variation was observed. Across the north west Solent, results were higher on average at the western end off Lymington and Keyhaven. Results were markedly lower from Lepe to Calshot, with a secondary peak off Stanswood. The higher results at the western end of this area may be due to the Pennington STW outfall, and given the UV upgrade here this pattern may not be so marked in future monitoring results. Within the south west Solent, results were lowest at Totland Bay Pier and were broadly similar from Yarmouth through to Thorness. Across the north east Solent, the average result steadily increased across the four nearshore RMPs from Browndown through to Spit Bank. Results were very similar across the three main RMPs in the south east Solent (Osbourne Bay, Kings Quay and Mother Bank Church Spire). Results in the central eastern Solent (East and West Ryde Middle and Ryde Pier) were slightly lower on average compared to other RMPs in the eastern Solent which were located closer to the shore.

Comparison of paired (same day) samples were possible for some native oyster RMP pairings. In most cases where comparisons were possible correlations were found, even between sites some distance away suggesting the entire Solent is under broadly similar influences. Along the north west coast of the Isle of Wight all possible site comparisons showed strong correlations. The same applied to site comparisons made along the north east coast of the Isle of Wight. Not all site parings along the western mainland coast showed correlations. Only one comparison was possible along the eastern mainland coast (Browndown and Gillkicker) where there was a correlation.

Across the two cockle RMPs the proportion of results exceeding 4600 *E. coli* MPN/100g suggested class B compliance was unlikely. This may imply that there are higher levels of contamination in the intertidal here relative to oyster beds in the subtidal, but caution should be exercised when comparing results from different species. A broadly similar pattern was observed for razors at these two locations, but much fewer samples of this species were taken.

Most of the native oyster RMPs in the north-west Solent had fairly consistent *E. coli* levels from 2003 to present. West Lymington River appeared to a decrease from 2003 to 2010 before sampling stopped here. There appears to have been a slight increasing trend since 2010 here. In the south-west Solent, most native oyster RMPs have had a slight increase in *E. coli* levels from 2003 to 2008, but appear to have remained fairly constant since. All RMPs in the eastern Solent have shown reasonably consistent levels of *E. coli* throughout this period.

A difference in seasonality in native oyster RMPs is apparent between sites near the mainland coast and sites near the Isle of Wight Coast. No seasonality at all was apparent for the north west Solent as far east as Lepe. From Lepe to Calshot there was a general tendency for higher results in the autumn and winter. No seasonality was apparent at RMPs in the north east Solent. RMPs in the south west Solent all showed a pattern of higher results in the summer and autumn. Some RMPs in the south east Solent also showed a similar pattern but seasonality was not clear and consistent throughout this stretch. This suggests that the northern RMPs west of Lepe are under a different influence to those from Lepe to Calshot, and that RMPs in the north east Solent are under similar influences to each other. RMPs along the south west Solent are under similar influences to each other, but sources with varying seasonality are present along the south east Solent.

Correlations between *E. coli* levels and tidal state on the high/low tidal cycle were found at some RMPs. A tendency for higher results around low water was seen at Calshot, Yarmouth West and Newtown River Mouth suggesting the adjacent estuaries are of significance at these locations. A tendency for higher results on the ebb tide was seen at Browndown, Gillkicker and Mother Bank Church Spire suggesting sources to the east are of significance to these. No clear patterns were apparent at South West Sewer Outfall, North West Sewer Outfall, Haslar, Spit Bank or West Ryde Middle when the data was plotted, despite the significant correlations.

Correlations were found between the spring neap cycle and *E. coli* results for South West Sewer outfall, North East Sewer outfall, Off Stanswood, Calshot, Totland Bay Pier, Yarmouth East, Yarmouth West, Newtown River Mouth, Totness, Off Browndown, Gillkicker Point, Spit Bank, Mother Bank Church Spire, West Ryde Middle, and for both cockle RMPs. At most of the native oyster RMPs, higher results tended to occur around the neap tide where less water is exchanged, although this pattern was not apparent for all.

No influence of rainfall was detected at Haslar Wall, East Ryde Middle or Ryde Sands (razors) although the latter was only sampled on 11 occasions and an influence of rainfall on cockles was found here. The influence of rainfall typically peaked around 3 days after the event, with some exceptions in the north west Solent

(South West Sewer Outfall to East Lymington River) which was less consistent and more delayed.

APPENDICES

APPENDIX I
HUMAN POPULATION

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

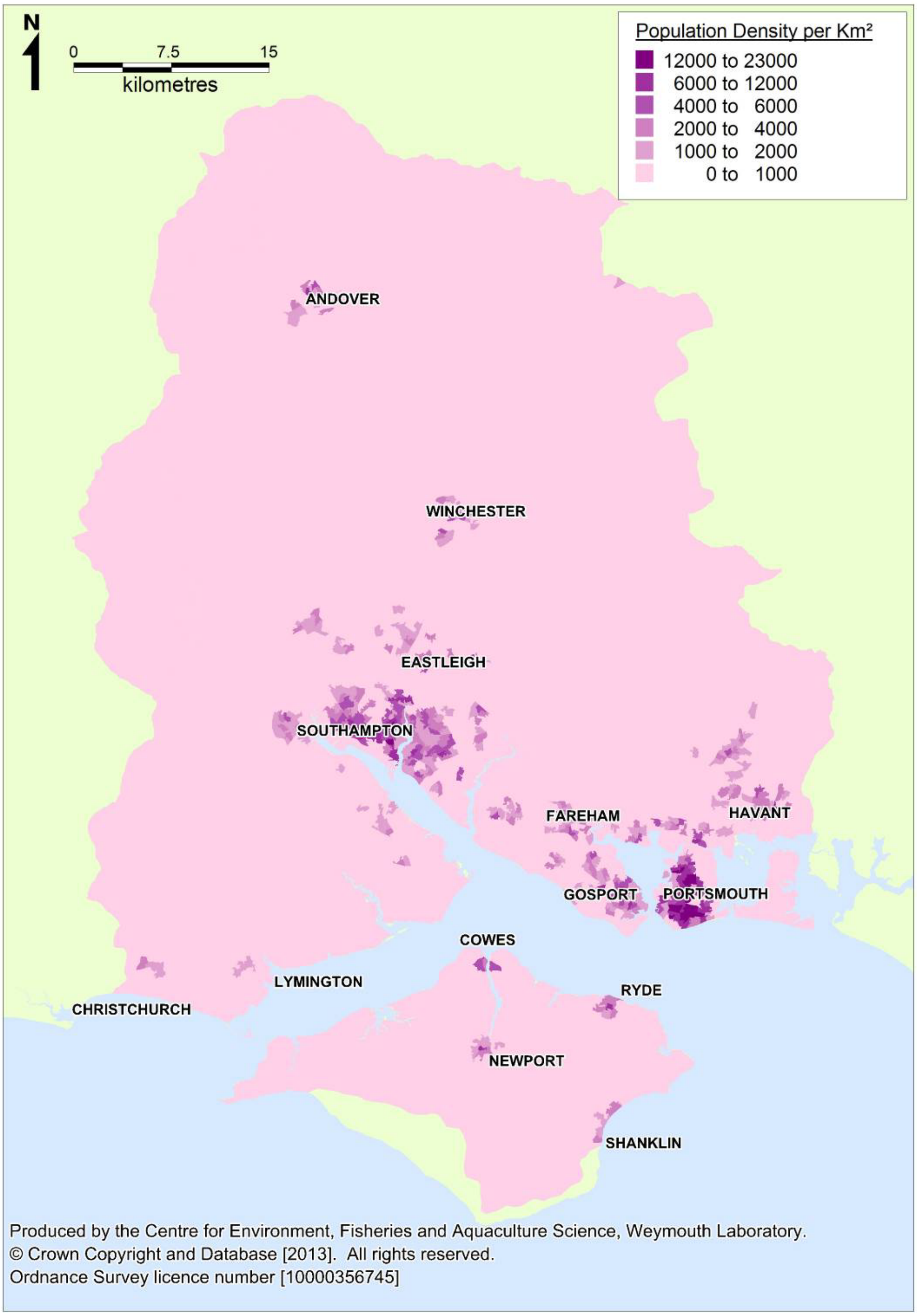


Figure I.1 Human population density in census areas in the Solent Catchment.
Source: ONS, Super Output Area Boundaries (Lower layer). Crown copyright 2004. Crown copyright material is reproduced with the permission of the Controller of HMSO.

Total resident population within the Solent catchment area was about 1,513,000 at the time of the last census. Of these just under 140,000 reside on the Isle of Wight, so the majority of sewage will originate from the mainland. Figure I.1 indicates that population densities are highest adjacent to the coast with a few exceptions, such as the towns of Andover, Winchester and Eastleigh. Southampton and Portsmouth represent the largest conurbations within the Solent catchment with population densities of up to 23,000 people per km². On the Isle of Wight population densities are highest along the north coast. Consequently, the stretch of coast between Southampton and Havant, on the east of catchment and the north east coast of the Isle of Wight are 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 II. Comparatively, the majority of the catchment which is more rural in character supports a much lower population density. To the west of Southampton lies the New Forest National Park and to the east lies the South Downs National Park.

The area receives significant influxes of visitors, attracted by the abundance of heritage sites, scenic landscapes, leisure facilities, outdoor pursuits and numerous events, shows and festivals such as the Southampton Boat Show and the Isle of Wight Festival. A large proportion of the catchment falls within the county of Hampshire the most visited county in the south east and the 6th most visited county nationally (Hampshire County Council, 2011). In 2008 37 million day tourists visited Hampshire and 3.8 million overnight trips made. A study conducted in 2010 to 2011 reveals that the Isle of Wight attracts around 2 million plus visitors each year (Visit Isle of Wight, 2011). During the peak of the festival season the population of the Isle of Wight almost doubles (Isle of Wight Council, pers comm). Therefore, total population will be highest in summer and lowest in winter, and volumes of sewage received by sewage treatment works serving the area will fluctuate accordingly.

APPENDIX II
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: SEWAGE DISCHARGES

Details of consented sewage discharges within the hydrological catchments draining to the survey area were taken from the Environment Agency's national discharge database (July 2012). For most of these it was not possible to physically verify their locations during the shoreline survey, so it is possible that there are some minor inaccuracies in the data presented. The locations of water company owned continuous sewage works discharges are shown in Figure II.1, and further details of these treatment works are presented in Table II.1.

There are three major sewage treatments works discharging direct to the Solent (Pennington, Peel Common and Budds Farm STWs) all of which provided secondary treatment until March 2013, at which point UV disinfection was added (Environment Agency 2009 a&b). They discharge via sea outfalls to depths of about 2m, 16m and 20m below chart datum respectively. As Pennington STW discharges to much shallower water, it has more potential to impact on nearby benthic shellfish stocks. Prior to these upgrades, their impacts were likely to be significant and widespread as the estimated bacterial loadings the generated ranged from $5.4x10^{13}$ to $3.6x10^{14}$ faecal coliforms per day (Table II.1). The UV disinfection should reduce this by about 3 orders of magnitude on average, although no final effluent testing data was available at the time of writing. It should be noted that UV disinfection is likely to be less effective against viruses than bacteria (e.g. Tree et al, 1997). There is also a small primary works at Thorns Beach which discharges direct to the Solent, although the maximum permitted discharge volume is less than $10m^3$/day.

There are also a significant number of large (secondary treated) discharges to Southampton Water or the lower reaches of rivers discharging to this water body (Test, Itchen and Hamble). Six major secondary sewage works are permitted to discharge a combined dry weather flow of just over 100,000 m^3 per day to tidal waters here, so the ebb plume from here is likely to be a further significant contaminating influence. Additionally, most major watercourses such as the Lymington River and the Beaulieu River receive some sewage effluent and so the plumes emanating from these river mouths also represent a source of sewage related contamination. Effluent from the main settlements on the Isle of Wight is treated at Sandown and discharged via a long sea outfall off the south east coast of the island, and so should not influence water quality within the Solent.

As well as the continuous sewage works, there are a large number of intermittent overflow discharges associated with the sewerage networks. The locations of intermittent discharges within 2km of the Solent classification zone boundaries are shown in Figure II.2 and further details of these are presented in Table II.3, including summary information on recorded spill events for the period January 2009 to March 2012. From the information on the database it was not possible to determine whether these outlets were for storm or emergency discharges or both. There were some mismatches between discharge names and locations between the details in the national discharge database and the spreadsheets containing the spill data. These were generally resolved by comparison of permit numbers, names and mapped locations, but it is possible that there are some mismatches in Table II.3.

Figure II.2 also shows the locations of private sewage discharges within 2km of the classified area, and Table II.4 shows the details of the larger private discharges with consented maximum flows of over $5m^3$/day.

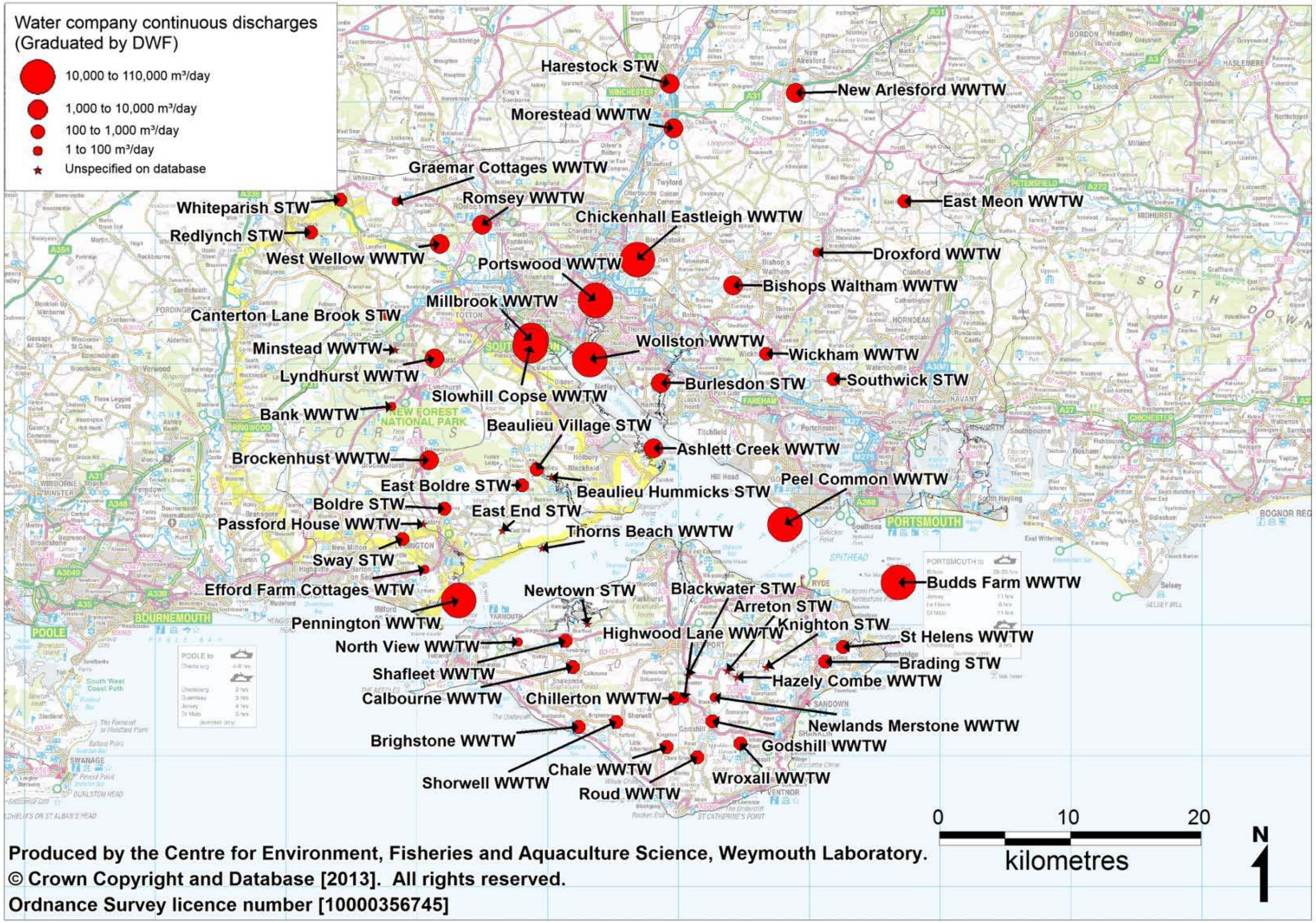


Figure II.1 Water company sewage treatment works discharging within the Solent catchment and to nearby coastal waters

Table II.1 Details of the continuous water company sewage discharges

Name	NGR	DWF (m^3/day)	Treatment Type	Estimated bacterial loading ***	Receiving environment
Arreton STW	SZ5370086500	Unspecified	Unspecified		Arreton Stream
Ashlett Creek WWTW	SU4807003510	3024	Secondary	9.98×10^{12}	Southampton Water
Bank WWTW	SU2806006730	38	Reedbed		Highland Water
Beaulieu Hummicks STW	SU4028001350	50*	Secondary	1.65×10^{11}	Beaulieu Estuary
Beaulieu Village STW	SU3913001900	216	Secondary	7.13×10^{11}	Beaulieu Estuary
Bishops Waltham WWTW	SU5414015980	3100	Secondary	1.02×10^{13}	River Hamble
Blackwater STW	SZ5071086180	Unspecified	Unspecified		Merstone Stream
Boldre STW	SZ3209098890	200	Secondary	6.60×10^{11}	Lymington River
Brading STW	SZ6120087210	390	Secondary	1.29×10^{12}	River Yar (Eastern)
Brighstone WWTW	SZ4232082220	428	Unspecified		Brighstone Stream
Brockenhust WWTW	SU3090002600	1233	Tertiary (Biological)		Lymington River
Budds Farm WWTW	SZ6679093250	108853	Secondary to March 2013, UV thereafter	3.59×10^{14} (secondary) 3.05×10^{11} (UV)	Solent
Burlesdon STW	SU4861008500	1550	Secondary	5.12×10^{12}	Hamble Estuary
Calbourne WWTW	SZ4190086800	177	Unspecified		Caul Bourne
Canterton Lane Brook STW	SU2758013690	9	Secondary	2.97×10^{10}	Cadnam River
Chale WWTW	SZ4905080680	117	Unspecified		River Medina
Chickenhall Eastleigh WWTW	SU4684017930	32000	Tertiary (Biological)		River Itchen
Chillerton WWTW	SZ4970084390	220	Land Irrigation		Sheat Stream
Droxford WWTW	SU6057518493	10	Unspecified		Groundwaters
East Boldre STW	SU3802000700	284	Unspecified		Hatchet Stream
East End STW	SZ3652097230	Unspecified	Unspecified		Sowley Stream
East Meon WWTW	SU6726022410	175	Secondary	5.78×10^{11}	River Meon
Efford Farm Cottages WTW	SZ3056594256	13.9	Secondary	4.59×10^{10}	Avon Water
Godshill WWTW	SZ5257082660	552	Unspecified		Godshill Stream
Graemar Cottages WWTW	SU2839022390	20	Secondary	6.60×10^{10}	River Blackwater
Harestock STW	SU4928031410	6330	Unspecified		River Itchen
Hazely Combe WWTW	SZ5446086040	Unspecified	Unspecified		Arreton Stream
Highwood Lane WWTW	SZ5041084371	16	Secondary	5.28×10^{10}	River Medina
Knighton STW	SZ5670086760	Unspecified	Unspecified		Knighton Stream
Lyndhurst WWTW	SU3132010400	1182	Tertiary (Biological)		Bartley Water
Millbrook WWTW	SU3871011760	40007	Secondary	1.32×10^{14}	River Test
Minstead WWTW	SU2830011030	Unspecified	Unspecified		Fleet Water
Morestead WWTW	SU4958027990 &	9933	Secondary	3.28×10^{13}	Soakaway

	SU4867027890				
New Arlesford WWTW	SU5892030690	1153	Secondary	$3.80x10^{12}$	Soakaway
Newlands Merstone WWTW	SZ5270084490	12	Secondary	$3.96x10^{10}$	Merstone Stream
Newtown STW	SZ4302090100	13.8	Unspecified		Newtown River
North View WWTW	SZ3772088710	35	Secondary	$1.16x10^{11}$	Thorley Brook
Passford House WWTW	SZ3047097740	Unspecified	Unspecified		Passford Water
Peel Common WWTW	SZ5810097700	59683	Secondary to March 2013, UV thereafter	$1.97x10^{14}$ (secondary) $1.67x10^{11}$ (UV)	Solent
Pennington WWTW	SZ3315091870	16362	Secondary to March 2013, UV thereafter	$5.40x10^{13}$ (secondary) $4.58x10^{10}$ (UV)	Solent
Portswood WWTW	SU4362014840	27700	Secondary	$9.14x10^{13}$	Itchen Estuary
Redlynch STW	SU2189020030	290	Secondary	$9.57x10^{11}$	River Blackwater
Romsey WWTW	SU3495020620	7379	Tertiary (Biological)		River Test
Roud WWTW	SZ5140079900	756	Secondary	$2.49x10^{12}$	River Yar
Shafleet WWTW	SZ4133088810	177	Unspecified		Caul Bourne
Shorwell WWTW	SZ4520082600	100	Unspecified		Shorwell Stream
Slowhill Copse WWTW	SU3862011350	16317	Secondary	$5.38x10^{13}$	Southampton Water
Southwick STW	SU6182008820	540	Secondary	$1.78x10^{12}$	River Wallington
St Helens WWTW	SZ6255088320	300	Unspecified		River Yar (Eastern)
Sway STW	SZ2888096570	776	Secondary	$2.56x10^{12}$	Avon Water
Thorns Beach WWTW	SZ3953095870	8.3**	Maceration	$8.30x10^{10}$	Solent
West Wellow WWTW	SU3172019160	1834	Unspecified		River Blackwater
Whiteparish STW	SU2411022540	367	Tertiary (Biological)		River Blackwater
Wickham WWTW	SU5667010750	750	Secondary	$2.48x10^{12}$	River Meon
Woolston WWTW	SU4317010290	15000	Secondary	$4.95x10^{13}$	Itchen Estuary
Wroxall WWTW	SZ5470080950	875	Unspecified		Wroxall Stream

* Estimated from population equivalent. ** Maximum permitted daily flow rather than DWF. ***Faecal coliform cfu/day, based on consented dry weather flow and base flow averages for treatment type from Table II.2 for sewage works where both were specified. *Data from the Environment Agency*

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

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

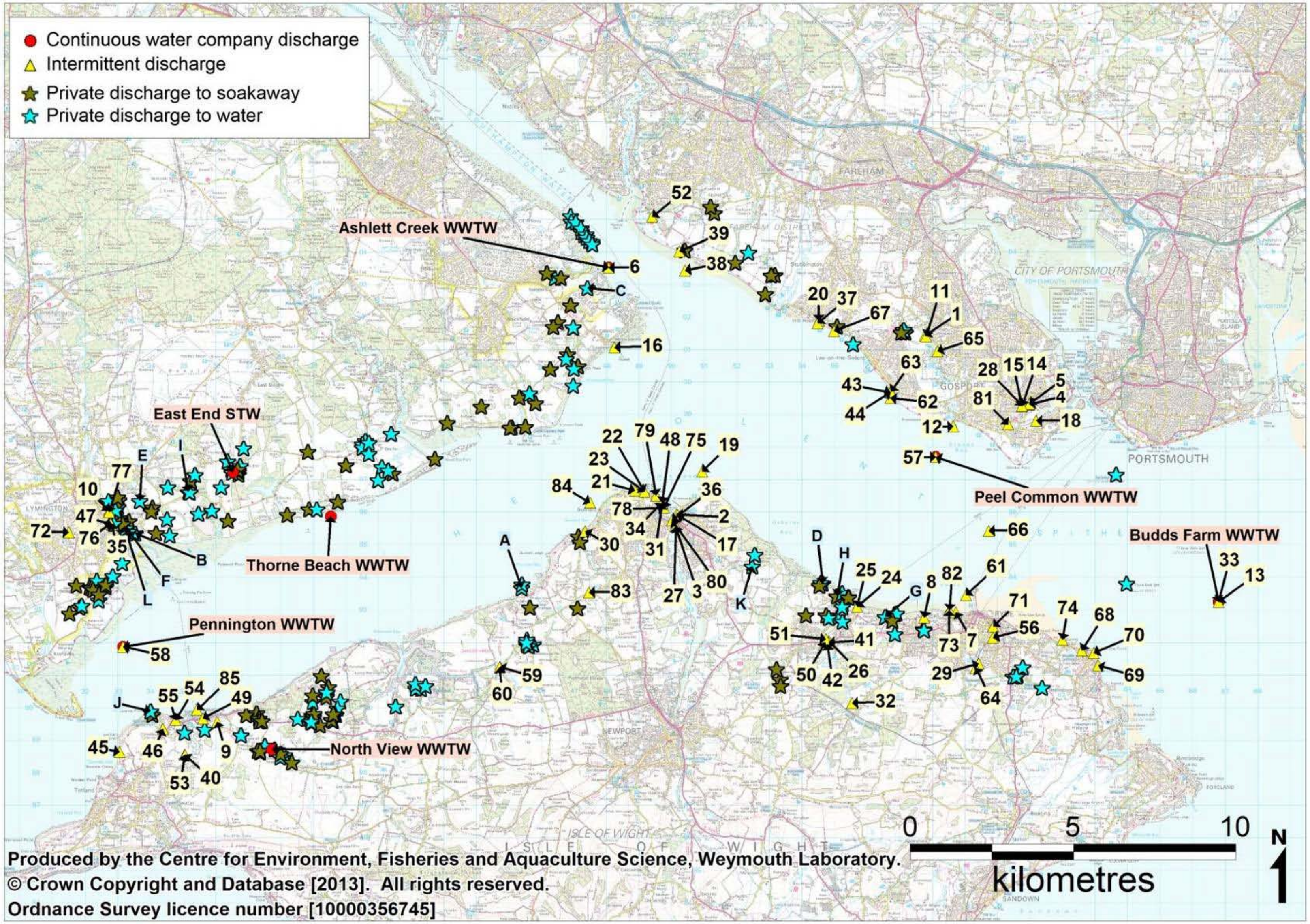


Figure II.2 Intermittent and private discharges within 2km of the classified zones within the Solent.

Table II.3. Details of nearby intermittent discharges and summary of spill data, where available, for Jan 2009-Mar 2012

No.	Name	NGR	No. spill events	Total event duration (hrs)	% time spilling (Jan 2009-Mar 2012)
1	Acorn Close PS	SU5777001430	Not monitored		
2	Albany PS	SZ5014095930	7	0.74	<0.1%
3	Albany Rd PS	SZ5011095580	Not monitored		
4	Alver Road CEO	SZ6097099320	Monitored but no spills recorded		
5	Alver Road PS	SZ6098099330	Monitored but no spills recorded		
6	Ashlett Creek WWTW	SU4807003510	1	2.08	<0.1%
7	Augusta Rd. CSO	SZ5872092930	Monitored but no spills recorded		
8	Binstead (Ladies Walk) WPS CSO	SZ5775092760	98	5.96	2.1%
9	Bouldnor PS	SZ3604089560	41	0.52	0.1%
10	Bridge Rd. CSO	SZ3273096040	Monitored but no spills recorded		
11	Broomfield Crescent	SU5780001400	Not monitored		
12	Browndown PS	SZ5864098640	2	1.4	<0.1%
13	Budds Farm WWTW	SZ6679093250	Not monitored		
14	Bury Cross Hospital PS	SZ6076099270	Not monitored		
15	Bury Road CEO	SZ6075099260	1	0.17	<0.1%
16	Calshot Car Park CEO	SU4824001060	Monitored but no spills recorded		
17	Castle Street CSO	SZ5019095910	Monitored but no spills recorded		
18	Clayhall Road/Dolphin Way PS	SZ6119098810	Monitored but no spills recorded		
19	Cowes (Springhill) Headworks WPS	SZ5093097250	2042	0.88	6.3%
20	Crofton Lane CSO	SU5451001890	Monitored but no spills recorded		
21	Egypt Point PS	SZ4887096670	4756	0.61	10.2%
22	Esplanade Cowes CEO	SZ4917096630	11	7.51	0.3%
23	Esplanade WPS	SZ4917096630	Monitored but no spills recorded		
24	Fishbourne PS	SZ5569093100	Not monitored		
25	Fishbourne Wier CSO	SZ5569093100	Not monitored		
26	Five Barge Lane CSO	SZ5483092040	Not monitored		
27	Floating Bridge CSO	SZ5014095560	Monitored but no spills recorded		
28	Foster Road WPS CEO	SZ6076099270	1	0.8	<0.1%
29	Great Preston Road CSO	SZ5942091350	82	1.53	0.4%
30	Gurnard PS	SZ4734095410	102	51.45	18.4%
31	Harbour Lights WPS	SZ4971096280	Not monitored		
32	Havenstreet PS	SZ5553090140	Not monitored		
33	Henderson Road WPS	SZ6679093250	Not monitored		
34	High Street Cowes CEO	SZ4971096280	Not monitored		

No.	Name	NGR	No. spill events	Total event duration (hrs)	% time spilling (Jan 2009-Mar 2012)
35	High Street Lymington CSO	SZ3279095650	Not monitored		
36	High Street PS	SZ5000095750	Not monitored		
37	Hill Head PS	SU5448001800	34	2.51	0.3%
38	Hook Park WPS (outlet 1)	SU5040003420	3	4.08	<0.1%
39	Hook Park WPS (outlet 2)	SU5023004010	Not monitored		
40	Kings Manor CEO	SZ3504088550	Monitored but no spills recorded		
41	Kite Hill PS	SZ5482092000	Not monitored		
42	Kite Hill Wootton CSO	SZ5478091950	13	10.46	0.5%
43	Lakeside Lee-on-Solent CSO	SZ5671099670	Monitored but no spills recorded		
44	Lakeside WPS	SZ5671099680	Monitored but no spills recorded		
45	Linstone Chine CSO	SZ3305088630	3	0.74	<0.1%
46	Linstone Drive CSO	SZ3438089350	Monitored but no spills recorded		
47	Lymington Slipway CSO	SZ3280095610	2	0.52	<0.1%
48	Market Hill CSO	SZ4970096290	195	3.2	2.2%
49	Mill Road/Tennyson Car Park	SZ3560089670	Not monitored		
50	Mill Square CSO	SZ5471092010	13	1.11	0.1%
51	New Road (Wootton) CEO	SZ5473092100	12	3.7	0.2%
52	Newtown Road CEO	SU4939005070	2	2.52	<0.1%
53	Norton Green CSO	SZ3505088550	2	0.29	<0.1%
54	Norton Headworks WPS	SZ3477089620	Not monitored		
55	Norton WPS CSO	SZ3477089620	174	1.71	1.0%
56	Park Road (Ryde) CSO	SZ5986092150	11	1.03	<0.1%
57	Peel Common WWTW	SZ5810097700	9	117.81	3.7%
58	Pennington WWTW	SZ3315091870	Not monitored		
59	Porchfield Main Rd. PS CSO	SZ4473091250	96	11.26	3.8%
60	Porchfield WPS	SZ4472091240	Not monitored		
61	Prince Consort WPS	SZ5903093450	Monitored but no spills recorded		
62	Queens Road Lee-on-Solent CEO	SZ5672099510	Monitored but no spills recorded		
63	Queens Road PS	SZ5673099710	Not monitored		
64	Rosemary Lane CSO	SZ5933091220	10	1.26	<0.1%
65	Rowner PS	SU5816000950	Not monitored		
66	Ryde (Appley Park) Headworks PS	SZ5973095430	2017	1.35	9.5%
67	Salterns Rd. Stubbington CSO	SU5498001560	Monitored but no spills recorded		
68	Salterns WMP CSO	SZ6259091750	52	2.33	0.4%
69	Seagrove WPS CSO	SZ6309091290	Monitored but no spills recorded		

No.	Name	NGR	No. spill events	Total event duration (hrs)	% time spilling (Jan 2009-Mar 2012)
70	Seaview WPS	SZ6296091670	20	2.34	0.2%
71	Simeon Street CSO	SZ5987092490	15	2.42	0.1%
72	Southern Rd./Highfield Av. CSO	SZ3149095380		Not monitored	
73	Spencer Road CSO	SZ5852092990	3	0.26	<0.1%
74	Springvale WPS CSO	SZ6199092090		Monitored but no spills recorded	
75	St Mary Road WWPW CSO	SZ4976096140		Not monitored	
76	Station St. Lymington No.2 CSO	SZ3277095660		Not monitored	
77	Station St. Lymington No.1 CSO	SZ3273096000		Not monitored	
78	Terminus Rd. CSO	SZ4976096140		Not monitored	
79	The Parade Cowes PS	SZ4952096520		Not monitored	
80	Thetis Wharf PS	SZ5000095750		Not monitored	
81	Village Road PS	SZ6033098700	19	2.88	0.2%
82	Westwood Road PS	SZ5853092990		Not monitored	
83	Whiteford Bridge CSO	SZ4746093530	3	0.24	<0.1%
84	Woodvale/Gurnard Headworks PS	SZ4749096300	33	63.72	7.4%
85	Yarmouth PS	SZ3542089930	1	0.12	<0.1%

Data from the Environment Agency.

The main clusters of intermittent discharges are associated with the towns of Norton, Cowes, Ryde and Gosport. On this basis, coastal waters off these towns may be more prone to contamination episodes from intermittent discharges. The three main sewage works all have overflow discharges from their long sea outfalls, although only Peel Common has spill records. The main spillers in terms of % time active were Gurnard PS (18.4%), Egypt Point PS (10.2%), Ryde (Appley Park) Headworks PS, Woodvale/Gurnard Headworks PS (7.4%) and Cowes (Springhill) Headworks WPS (6.3%). All of the major spillers are therefore on the north coast of the Isle of Wight, with most around the Cowes area. The spill event duration data considered in this report does not provide an indication of volumes spilled, and the accuracy of the data cannot be verified. There are many further intermittent discharges outside of the 2km buffer set around the classified fishery, particularly around Southampton Water.

In addition to the water company owned discharges, there are a number of private discharges of potential significance. Where specified, these are generally treated by either septic tank or small treatment works such as package plants. The majority of these are small, serving one or a small number of properties and discharging less than $1m^3$/day. About 40% discharge to soakaway (and should have little effect on coastal waters) and about 60% discharge to either watercourses or coastal waters. The details of those with maximum consented flows of over $5m^3$/day are presented in Table VII.4.

Table VII.4 Details of nearby private sewage discharges with consented flow of over $5m^3$/day.

Ref	Name	NGR	Max Flow	Treatment type	Discharges to
A	Thorness Bay Holiday Park	SZ4539093680	568	Unspecified	Solent (via ditch)
B	Elmers Court Country Club	SZ3352595360	115	Package Plant	Lymington estuary
C	Fawley Generating Station	SU4741002890	114	Unspecified	Southampton Water
D	Woodside Beach Caravan Park	SZ5464393824	36	UV disinfection	Solent
E	Walhampton School	SZ3367096350	20	Unspecified	Watercourse
F	Sealink Terminal	SZ3332095420	18	Unspecified	Lymington estuary
G	Quarr Abbey	SZ5655092800	14	Unspecified	Watercourse
H	Woodside Nursing Home	SZ5507093426	11	Package Plant	Soakaway
I	South Baddesley School	SZ3515596634	10.25	Package Plant	Watercourse
J	Fort Victoria Cottages	SZ3400089900	9.7	Unspecified	Solent
K	Barton Manor Farm	SZ5247094350	7	Unspecified	Watercourse
L	Ferry Point	SZ3320095580	5.7	Unspecified	Lymington estuary

Data from the Environment Agency.

The largest of these is the Thorness Holiday Park, which is larger than several of the water company sewage works. It is likely that flows from here vary with season, peaking in the summer holidays.

APPENDIX III
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: AGRICULTURE

Agricultural land within the catchment is mainly used for arable farming, although there are some areas of pasture, particularly on the Isle of Wight and in the lower parts of the catchment on the mainland (Figure 1.2). Table III.1 and Figure III.1 present livestock numbers and densities for the sub-catchments draining to the Solent. This data was provided by Defra and is based on the 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, the data should give a good indication of the numbers of livestock within the catchment.

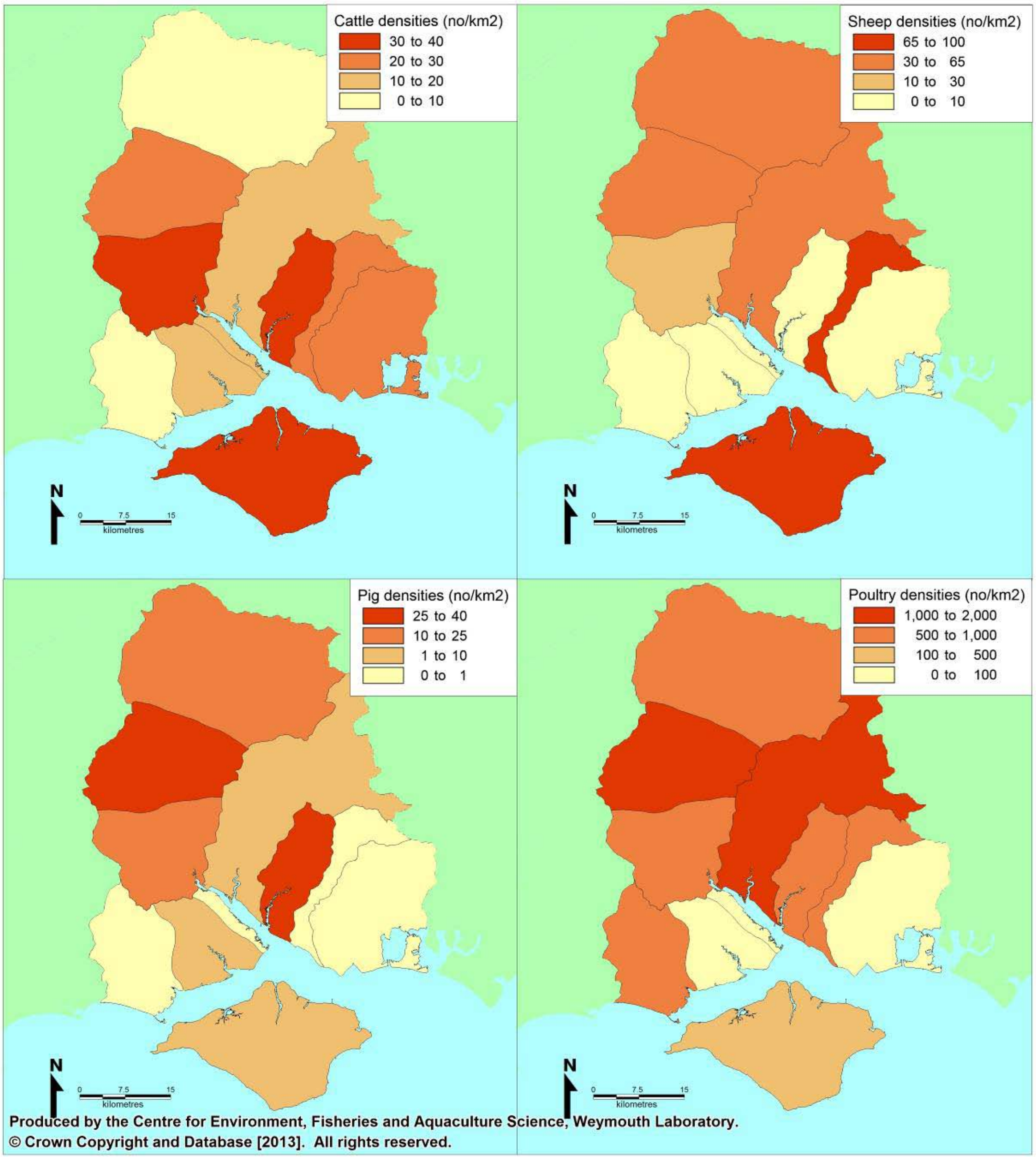


Figure III.1. Livestock densities within the Solent catchment
Data from Defra

Table III.1 Summary statistics from 2010 livestock census for the Solent catchment

	Numbers				Density (animals/km^2)			
Catchment name	Cattle	Sheep	Pigs	Poultry	Cattle	Sheep	Pigs	Poultry
Hamble	5,097	1,057	6,205	111,518	32.8	6.8	39.9	717.3
Isle of Wight	14,866	36,730	887	40,980	39.1	96.6	2.3	107.8
Itchen	8,991	15,369	5,095	911,288	17.5	30.0	9.9	1776.9
Meon	3,197	9,903	**	64,558	28.0	86.6	**	564.5
New Forest (A)	2,099	1,991	153	186,653	9.7	9.2	0.7	859.4
New Forest (B)	2,937	308	887	373	19.6	2.1	5.9	2.5
New Forest (C)	511	**	0	1,391	18.0	**	0.0	49.0
Test (Lower A)	9,664	3,976	3,638	204,231	37.1	15.2	14.0	783.2
Test (Lower B)	6,950	14,892	10,471	518,515	21.3	45.6	32.1	1589.3
Test (Upper)	6,209	28,633	8,407	460,382	9.4	43.5	12.8	700.0
Wallington	7,178	3,063	167	6,929	22.5	9.6	0.5	21.7
TOTAL	67,699	115,923	35,911	2,506,818	21.7	37.1	11.5	802.7

**Data suppressed for confidentiality reasons

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^{-1} wet weight)	Excretion rate (g day^{-1} wet weight)	Faecal coliform load (No. day^{-1})
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 significant numbers of grazing animals within the catchment with almost 70,000 cattle and over 100,000 sheep. The Isle of Wight supports the highest densities of both, so land runoff from here is likely to be most heavily impacts by grazers, although all major watercourses may be impacted to some extent. Some diffuse inputs associated with grazing livestock are therefore anticipated via direct deposition on pastures, and these may be locally significant in some places. Slurry is also collected from livestock sheds when cattle are housed indoors and subsequently applied to fields as fertilizer. Large numbers of poultry and some pigs are also raised within the catchment. Manure from pig and poultry operations is typically collected, stored and spread on nearby farm land (Defra, 2009). Sewage sludge may also be used as fertilizer, but no information on local practices was available at the time of writing.

The primary mechanism for mobilisation of faecal matter deposited or spread on farmland to coastal waters is via land runoff, so fluxes of livestock related contamination into the estuary 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’). Most, if not all major watercourses will be impacted to some extent by agriculture. Some of the smaller watercourses may also be impacted to some extent. Little was seen in the way of livestock during the shoreline survey (2 ponies at Pennington and 10 alpacas at Yarmouth). A small stream at Thorness Bay had a strong manure odour and contained very high levels of *E. coli* (280,000 cfu/100ml) suggesting significant livestock contamination of this watercourse at the time.

There is likely to be seasonality in levels of contamination originating from livestock. Numbers of sheep and cattle will increase significantly in the spring, with the birth of lambs and calves, and decrease in the autumn when animals are sent to market. Highest sheep counts on the grazing marshes on the south shore of the estuary are reported to occur from April to October. During winter cattle may be transferred from pastures to indoor sheds, and at these times slurry will be collected and stored for later application to fields. Timing of these applications is uncertain, although farms without large storage capacities are likely to spread during the winter and spring. Poultry/pig manure and sewage sludge may be spread at any time of the year. Peak levels of contamination from agriculture may therefore 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/slurry application, which is perhaps more likely in late winter or spring.

APPENDIX IV
SOURCES AND VARIATION AND MICROBIOLOGICAL POLLUTION: BOATS

The discharge of sewage from boats is potentially a significant source of bacterial contamination to shellfisheries. Boat traffic within the Solent is very heavy. It hosts three large commercial ports, the UK's principle cruise ship port, an abundance of marinas and a significant fishing fleet. Figure IV.1 presents an overview of boating activity derived from the shoreline survey, satellite images and various internet sources.

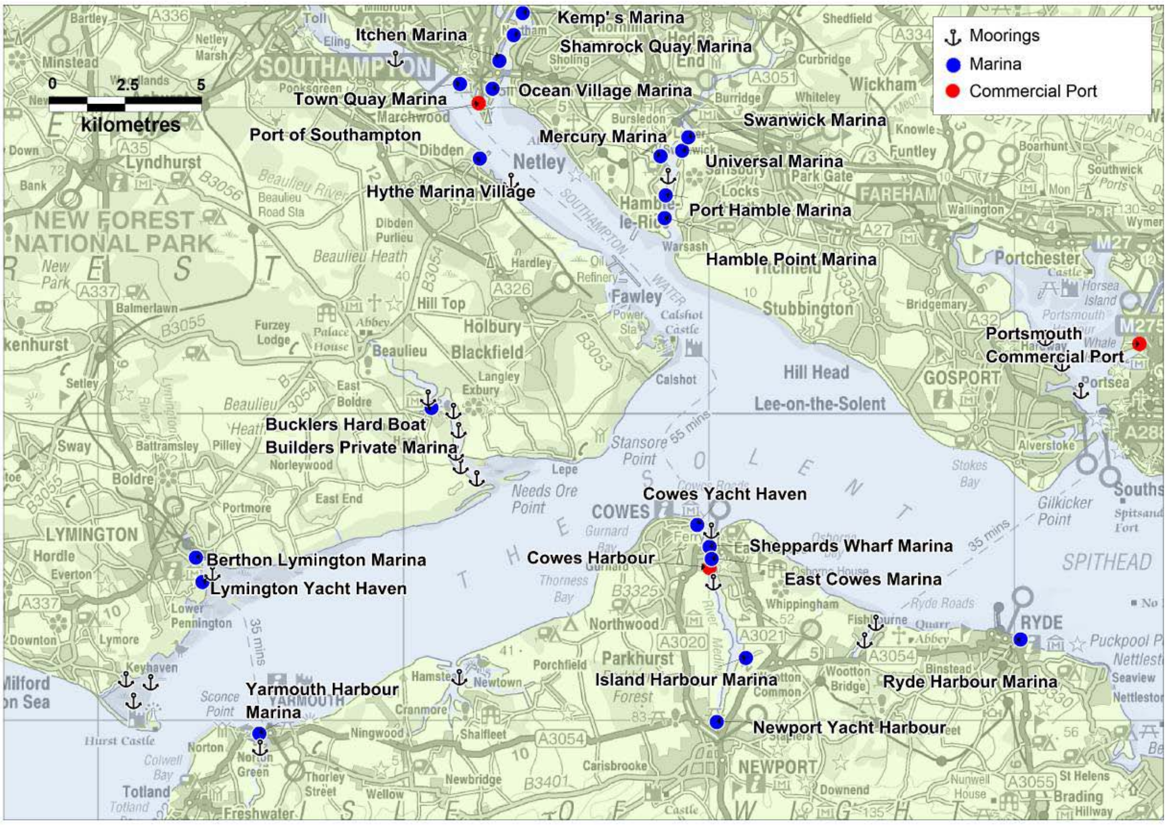


Figure IV.1 Locations of moorings, marinas and commercial ports in the Solent.

The Solent forms part of the route for major international shipping of freight within the UK, with approximately 100,000 commercial shipping movements each year. Three major commercial ports are situated around the Solent; the Port of Southampton, Portsmouth Commercial Port and Cowes Harbour. The Port of Southampton and Portsmouth Commercial port are situated outside the boundary for the Solent in terms of this survey, but the main shipping channel to Southampton runs through the eastern Solent. Vessels accessing Portsmouth Port approach through a channel in the very eastern end of the survey area.

Southampton Port holds the UK's second largest container terminal and is a key distribution hub for oil and liquid bulks (ABP, 2013). It is also the principal cruise port within the UK, transporting around half a million passengers each year. Portsmouth Port also handles large volumes of cargo such as fruit, and there is a naval base within the harbour. Cowes Harbour is a much smaller port involved in the timber, stone, petrol oil aggregates and ship building trades. Passenger and car ferries run hourly from Cowes, Fishbourne, Yarmouth and Ryde, linking the Isle of Wight to the mainland. Merchant shipping vessels are not permitted to make overboard discharges within 3 nautical miles of land[1] so vessels associated with the commercial port, cruise port and ferry terminals should be of no impact.

The Solent has a mixed fishery which supports around 140 commercial fishing vessels of varying size (Solent Pedia, 2011). These fishing vessels are mainly registered to the various ports that surround the Solent however some are registered outside the Solent for example, 13 are registered in Sussex and 25 in Langstone Harbour.

Recreational boat traffic is extremely heavy within the Solent. There are 21 marina's holding between 50 and 575 berths (Reeds, 2011) and numerous moorings (Figure IV.1). The moorings are located in the shallower more sheltered areas, principally the estuaries and harbours. Cowes hosts major yachting regattas such as Cowes Week, taking place in early August with around 1,000 yachts, 8,000 participants and numerous spectator boats taking to the waters. Sewage pumpout facilities are only available at a few of the marinas (Shepards Wharf, Yarmouth Harbour, Lymington Yacht Haven, Hythe, and the Harbour Authority Jetty at Hamble).

An abundance of sailing clubs and watersports centres operate from the Solent offering a variety of dinghy sailing, power boating, water skiing, windsurfing, kitesurfing and canoeing/kayaking. However, these smaller recreational boats are not large enough to contain onboard toilet facilities and therefore are therefore unlikely to make overboard discharges.

The more sizeable private vessels such as yachts, cabin cruisers and fishing vessels are likely to make overboard discharges from time to time. Those in overnight occupation on moorings or at anchor may be more likely to make overboard discharges, so higher impacts may be anticipated within moorings or anchorages. On this basis the estuaries and harbours such as the Medina, Lymington River, Beaulieu River, Yarmouth and Keyhaven are most at risk. Occupied yachts on pontoon berths may be less likely to make overboard discharges as this is somewhat antisocial in the crowded marina setting, and facilities on land are easier to access. Boats may also make overboard discharges whilst underway, so the main navigation channels may also be more susceptible to impacts from boat traffic. Peak pleasure craft activity is anticipated during the summer, 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.

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

APPENDIX V
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: WILDLIFE

The Solent and associated estuaries and harbours encompasses a diversity of habitats including sand and gravel banks, intertidal mudflats, saline lagoons, shingle beaches, reedbeds and grazing marsh. These features attract significant populations of birds and other wildlife. Consequently large areas have been designated as conservation areas and form part of the Solent European Marine Sites. The whole of the Solent and Southampton water is designated as a SPA and areas within the Solent are designated as SSSI, SAC, Ramsar and NNR, these protect the Solent's wildlife and habitats.

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 & Jones, 2000). Some areas of the Solent and adjacent estuaries are subject to annual counts of overwintering waterbirds. Average total counts over the five winters up to 2010/11 were 15,534 in the north west Solent, 12,810 in Portsmouth Harbour and 12,015 in Southampton Water (Holt *et al.*, 2012). The Medina Estuary, although relatively small in comparison, is also an important site for waterbirds, a total mean of 8,334 birds were recorded in the 753 hectare site between the winters 2008/09 and 2009/10 (Holt *et al.*, 2012). Other estuaries and areas of Solent shoreline were not subject to bird counts but will support significant populations where there are suitable habitats.

Geese and ducks will mainly frequent the grassland and saltmarsh, where their faeces will be carried into coastal waters via runoff into tidal creeks or through tidal inundation. Therefore RMPs within or near to the drainage channels from saltmarsh areas will be best located to capture contamination from this source. Waders, such as dunlin and oystercatchers forage upon shellfish and so will forage (and defecate) directly on 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. Due to the diffuse and spatially unpredictable nature of contamination from wading birds it is difficult to select specific RMP locations to best capture this, although they may well be a significant influence during the winter months.

Birds such as gulls and terns and relatively small numbers of waders remain in the area to breed in the summer, but the majority migrate elsewhere outside of the winter months. Bird numbers and potential impacts on the hygiene status of the fisheries are therefore much lower during the summer. The JNCC Seabird 2000 census recorded 339 breeding pairs of gulls and terns within the Solent, primarily within Southampton Water and in the mouths of the Lymington and Beaulieu and Hurst Spit on the mainland and Newtown Estuary on the Isle of Wight (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 seal tagging study undertaken by the South East Wildlife Trust in 2008 confirms that a colony of harbour seals, between 23 and 25 and a couple of grey seals are present within the Solent. The seals forage in the Eastern Solent and occasionally make foraging trips over to the Isle of Wight. The moulting and pupping season for Harbour seals is between June and August and for grey seals between September and December. In these months they will spend more time at their haul out sites situated to the east of the survey area in Langstone and Chichester Harbour and less time foraging for food and therefore will spend less time within the Solent survey area (Wildlife Trusts' South East Marine Programme, 2010). Consequently, the highest microbiological input in the Solent from seals will be between January and May. Bottlenose dolphins and harbour porpoises have also been sighted within the Solent, although their numbers are not known and are likely to be small. It is therefore concluded that marine mammals will be present within the Solent but only in small numbers and their presence will be unpredictable both spatially and temporally. Consequently their presence will not influence the sampling plan.

No other wildlife species which have a potentially significant influence on levels of contamination within shellfish within the survey area have been identified.

APPENDIX VI
METEOROLOGICAL DATA: RAINFALL

The nearest weather station for which uninterrupted rainfall records were available was at Stem Lane, New Milton, which is close to the mainland coast just to the west of Keyhaven. This should be representative of rainfall in the Solent area. Figure VI.1 presents a boxplot of daily rainfall records by month at Stem Lane.

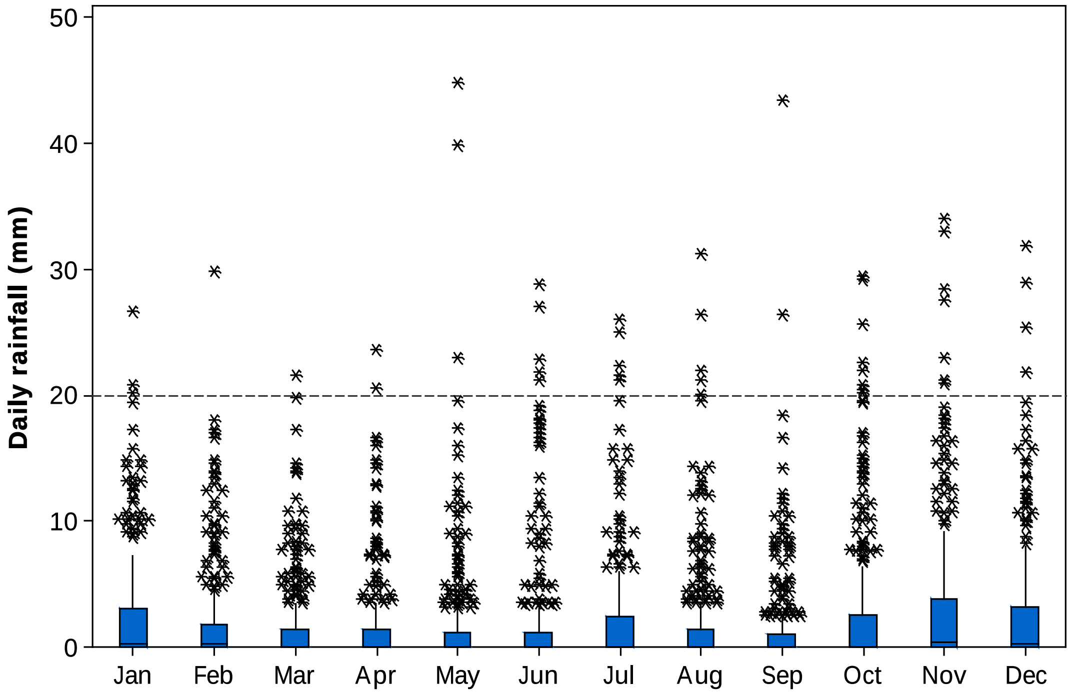


Figure VI.1 Boxplot of daily rainfall totals at Stem Lane, January 2003 to January 2012.
Data from the Environment Agency

Rainfall records from Stem Lane show an average of 824mm per year between 2003 and 2012. They indicate relatively low seasonal variation in average rainfall. Rainfall was lowest on average in March and April and highest on average from October to January with a secondary peak in July. Daily totals of over 20mm were recorded on 1.3% of days and 53.7% of days were dry. Higher rainfall events of over 20mm tended to occur most during the summer and autumn but 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 mobilisation 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 X and XI.

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).

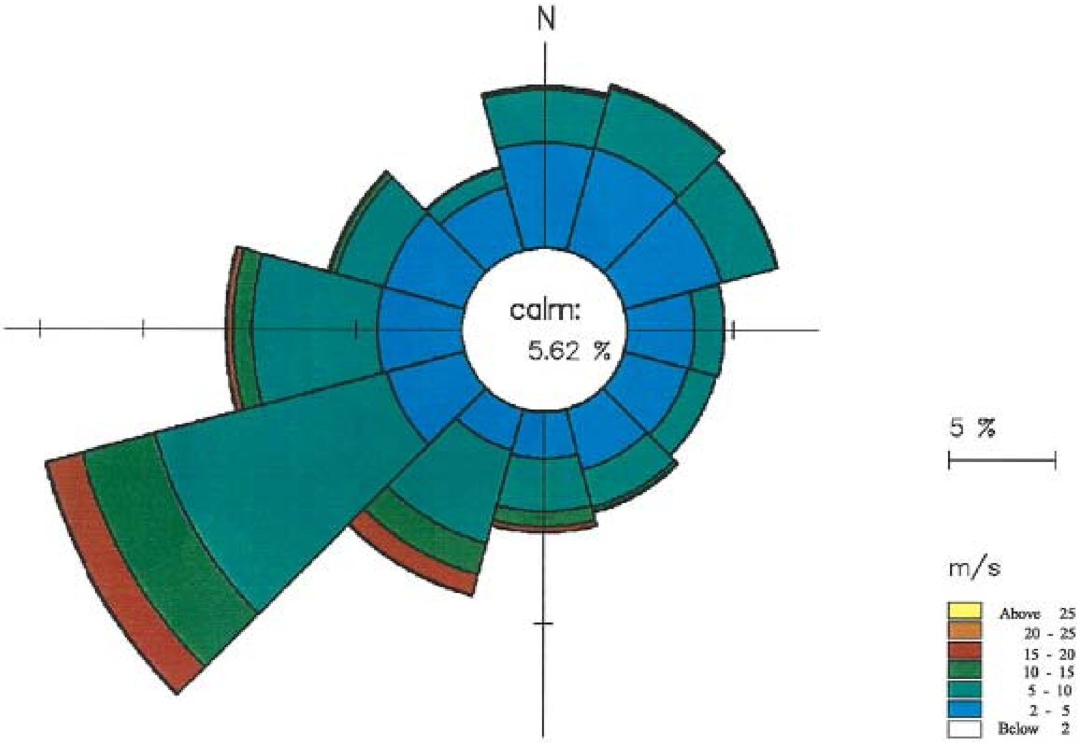


Figure VII.1 Wind rose for Southampton Water
Produced by ABPmer 2007. Contains public sector information licensed under the Open Government Licence v1.0

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. The Solent forms a channel between the Isle of Wight and the mainland which has a south-west to north-east aspect in its western half and a north-west to south-east aspect in its eastern half. The eastern half is therefore most exposed to the prevailing winds. The western half will be more sheltered, although the surrounding land will tend to funnel winds along the Solent to some extent.

APPENDIX VIII
HYDROMETRIC DATA: FRESHWATER INPUTS

The catchment area draining into the Solent is around 3,050 km^2 and is illustrated in Figure VIII.1. There are several freshwater inputs into the Solent, including the Lymington and Beaulieu rivers in the New Forest; the rivers Test, Itchen and Hamble which drain into Southampton Water; The River Medina and the Eastern Yar on the Isle of Wight. There are also several other smaller streams that discharge into the Solent. Rivers in this catchment flow through both rural and urban areas. These rivers will all receive microbiological pollution from point and diffuse sources such as STW discharges and urban and agricultural runoff. They are therefore a potentially significant source of microbiological contamination for the shellfisheries in the area.

The Rivers Test, Itchen and Meon originate in the northern reaches of the catchment where the dominant bedrock is chalk so a significant proportion of flows originate from groundwaters. These rivers flow south where the geology of the catchment changes to be dominated by low permeability clay bedrock. Most of the Test's course is through largely rural land. In contrast, large parts of the Itchen flow through the urban areas of Winchester, Eastleigh and Southampton.

The rivers Hamble, Lymington and Beaulieu originate in the clay areas and so will likely be dominated by run-off and more variable as a result. The River Medina and Eastern Yar originate in the South of the Isle of Wight where greensand dominates the bed rock. All of the rivers discharge in areas where the underlying bedrock has low to moderate permeability. The low permeability of much of the southern catchment's bedrock means that there are relatively high rainfall runoff rates that flow directly into the watercourses (Environment Agency, 2009c).

The Rivers Test, Itchen and Hamble discharge into Southampton Water and so their combined effect on shellfisheries in the Solent will result from the ebb plume from Southampton Water. The Meon, Beaulieu, Lymington, Medina, and Eastern Yar are all significant rivers which discharge direct to the survey area via estuaries of varying sizes. These and other watercourses will impact via the ebb plume from their estuaries. The profile of impacts from individual watercourses will vary depending on the shape and size of their estuaries. For example, a watercourse discharging direct to the Solent will create a more intense hotspot of contamination at its mouth compared to a similar watercourse which passes through a large estuary where there will be significant scope for dilution. In general, smaller watercourses will tend to drain directly to the Solent whereas larger ones will have more in the way of an estuary. The characteristics of the larger estuaries draining to the Solent are described in detail in Appendix IX.

Summary statistics for flow gauges on these rivers are presented in Table VIII.1. Some of these gauging stations are located a considerable distance upstream from the tidal limit, so do not represent the total discharge from these watercourses.

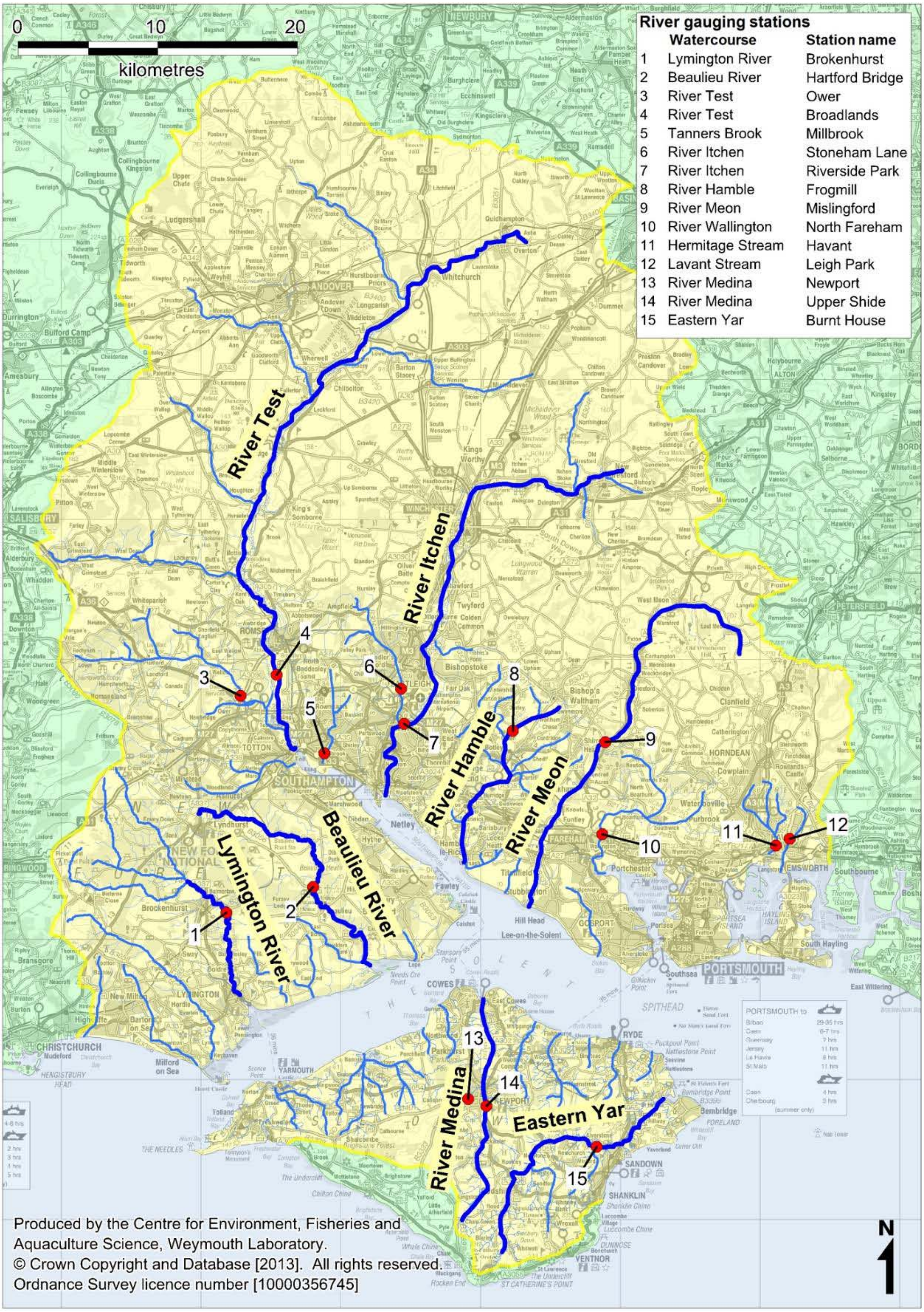


Figure VIII.1: Watercourses within the survey catchment area

Table VIII.1: Summary flow statistics for flow gauge stations on watercourses draining into the Solent

Watercourse	Station name	Period covered	Catchment area (km^2)	Mean flow (m^3s^{-1})	Q95[1] (m^3s^{-1})	Q10[2] (m^3s^{-1})
Lymington River	Brokenhurst	2003-2012	98.9	1.08	0.06	2.60
Beaulieu River	Hartford Bridge	2003-2008	149.8	0.66	0.03	1.57
River Test	Broadlands	2003-2012	1040.0	9.91	5.13	15.59
Blackwater	Ower	1976-2011	104.7	0.90	0.15	2.28
Tanner Brook	Millbrook	1977-2011	16.0	0.20	0.01	0.41
River Itchen	Riverside Park	2003-2012	415.0	5.51	3.04	8.42
Monks Brook	Stoneham Lane	1987-2011	43.3	0.25	0.03	0.62
River Hamble	Frogmill	2003-2012	56.6	0.44	0.12	0.80
River Meon	Mislingford	2003-2012	72.8	0.87	0.18	1.79
River Wallington	North Fareham	1955-2011	111.0	0.61	0.03	1.56
Hermitage Stream	Havant	2003-2012	17.0	0.18	0.02	0.42
Lavant Stream	Leigh Park	2003-2006	54.5	0.09	0.00	0.21
River Medina	Upper Shide	2003-2012	29.8	0.31	0.12	0.54
Eastern Yar	Burnt House	2003-2012	9.2	0.56	0.05	1.26

[1]Q95 is the flow that is exceeded 95% of the time (i.e. low flow). [2]Q10 is the flow that is exceeded 10% of the time (i.e. high flow). *Data from NERC (2012) and the Environment Agency*

Table VIII.1 indicates the majority of freshwater inputs in terms of volume (the Test and Itchen) are to Southampton Water, although other watercourses draining to smaller estuaries feeding into the Solent also carry significant volumes of runoff. A boxplot of the sum of mean daily flow records for all gauging stations is presented in Figure VIII.2. Boxplots showing mean daily flow record for individual gauging stations is presented in Figure VIII.3 to Figure VIII.12.

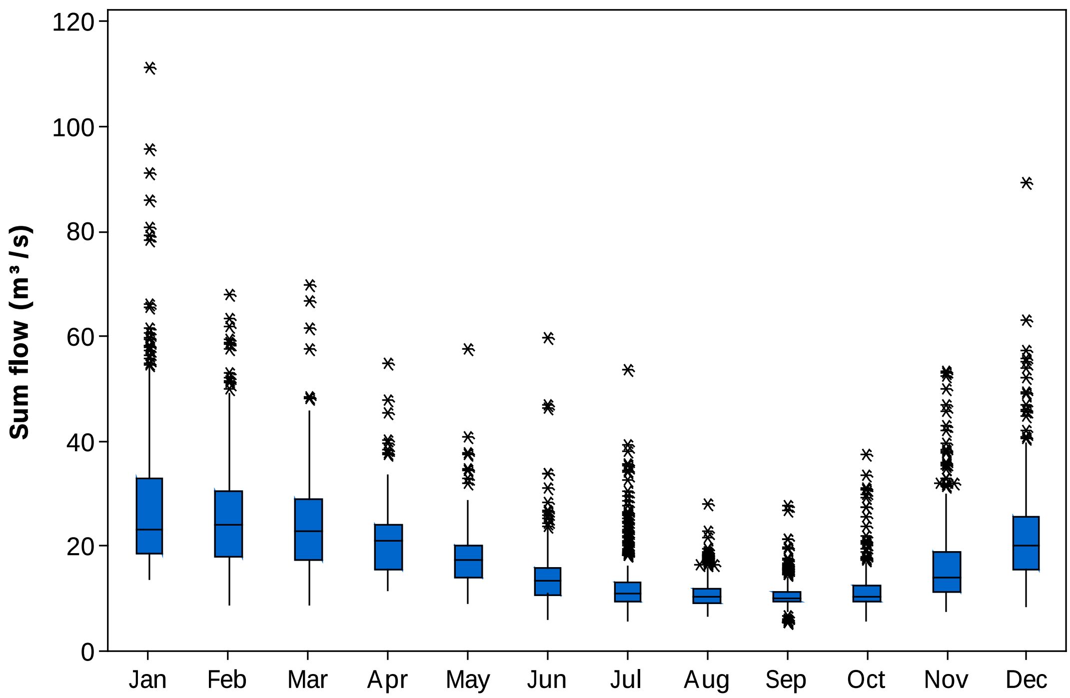


Figure VIII.2: Boxplots of the sum of mean daily flow records from all of the gauging stations relevant to the Solent.

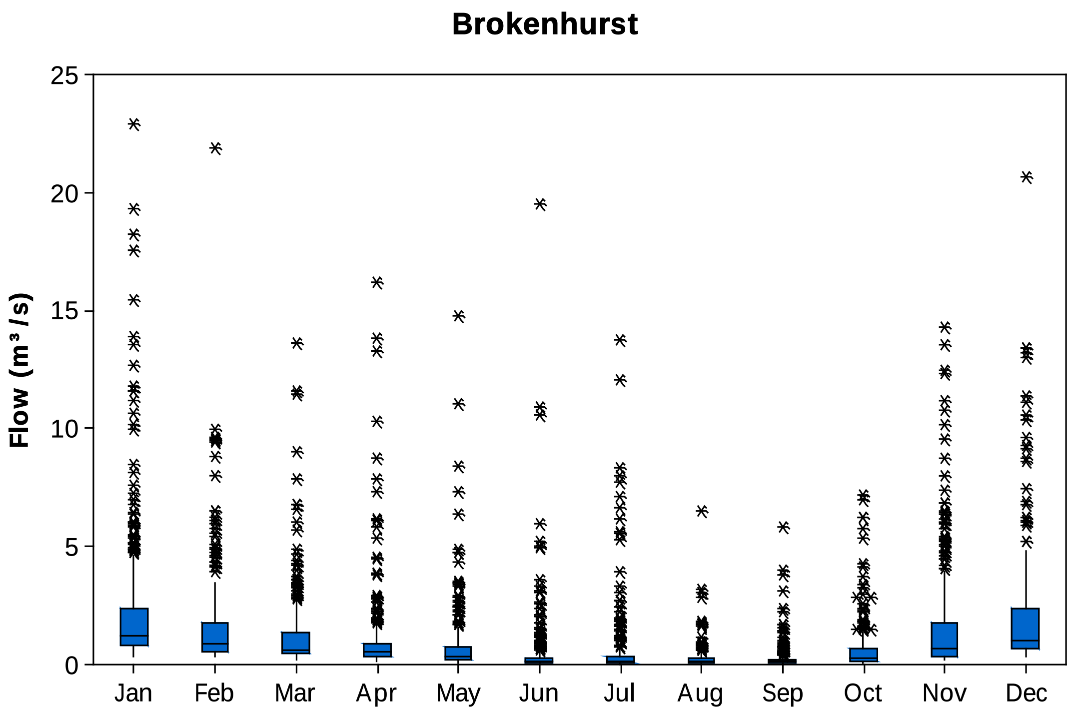


Figure VIII.3: Boxplots of the mean daily flow records from the Brokenhurst gauging station on Lymington River

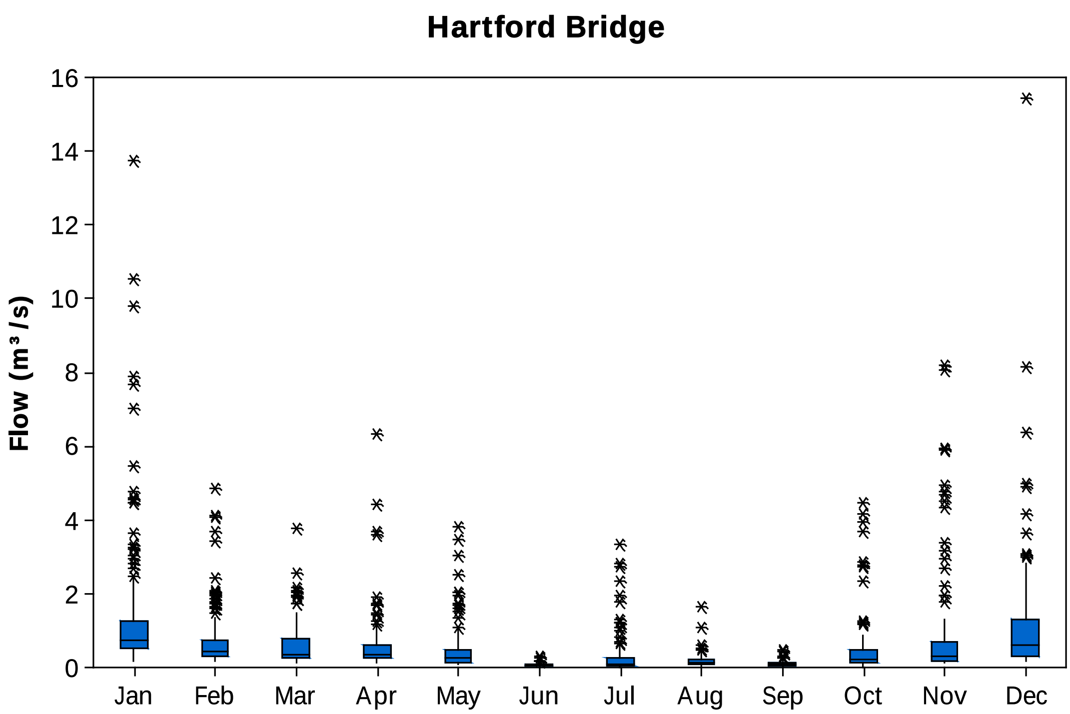


Figure VIII.4: Boxplots of the mean daily flow records from the Hartford Bridge gauging station on Beaulieu River

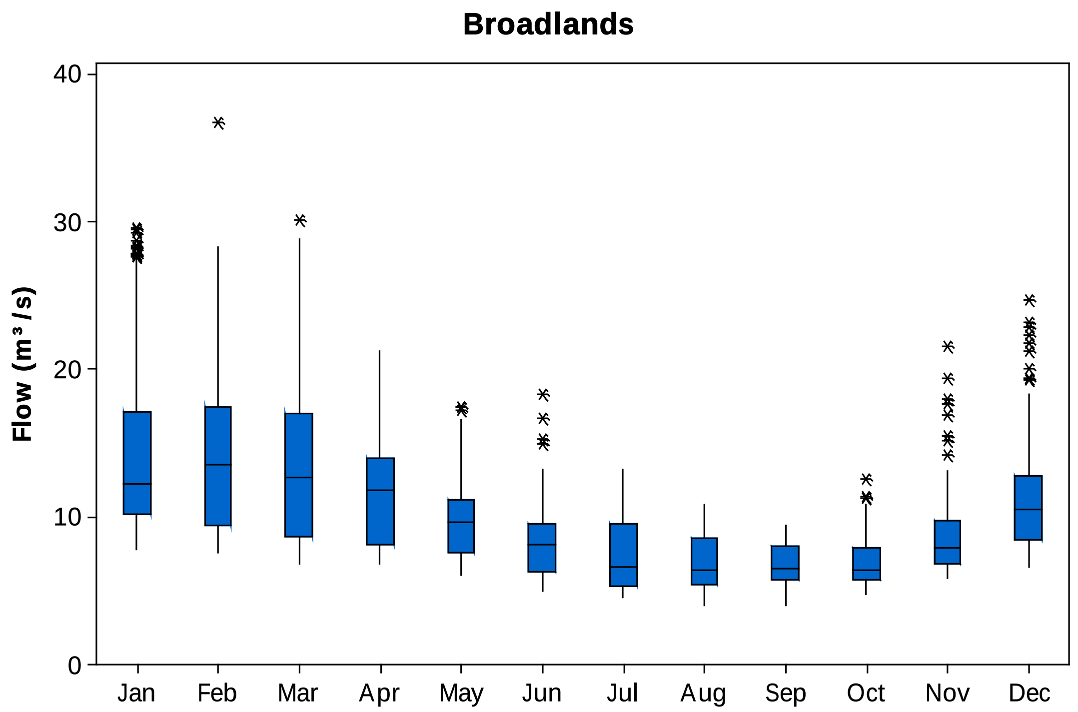


Figure VIII.5: Boxplots of the mean daily flow records from the Broadlands gauging station on River Test

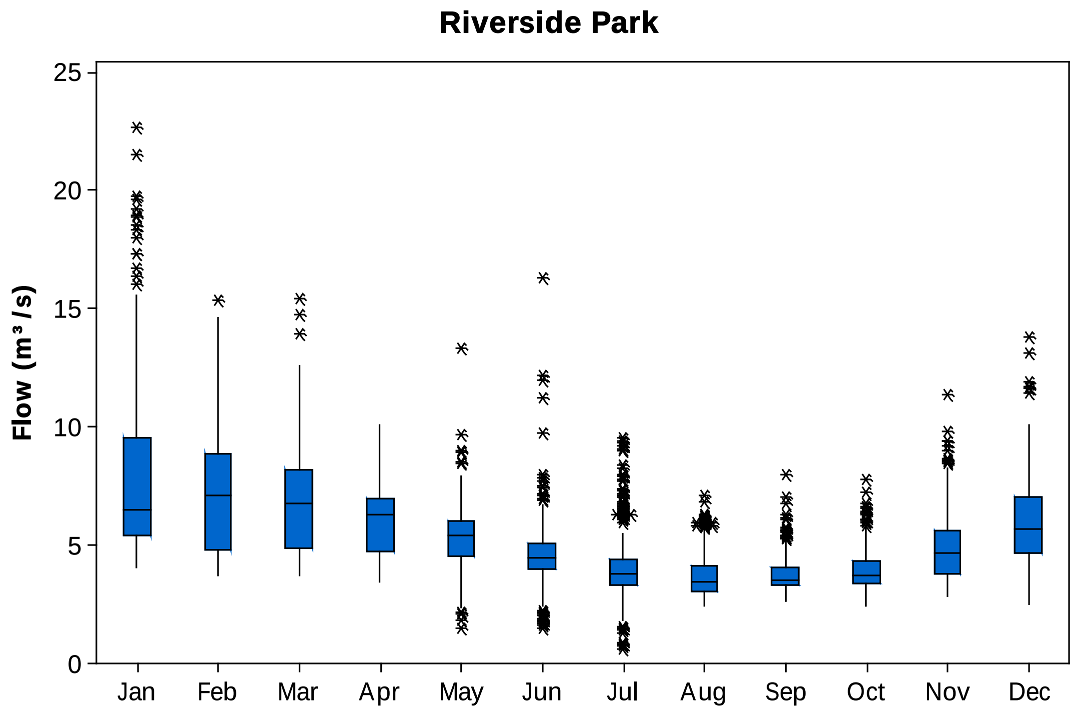


Figure VIII.6: Boxplots of the mean daily flow records from the Riverside Park gauging station on River Itchen

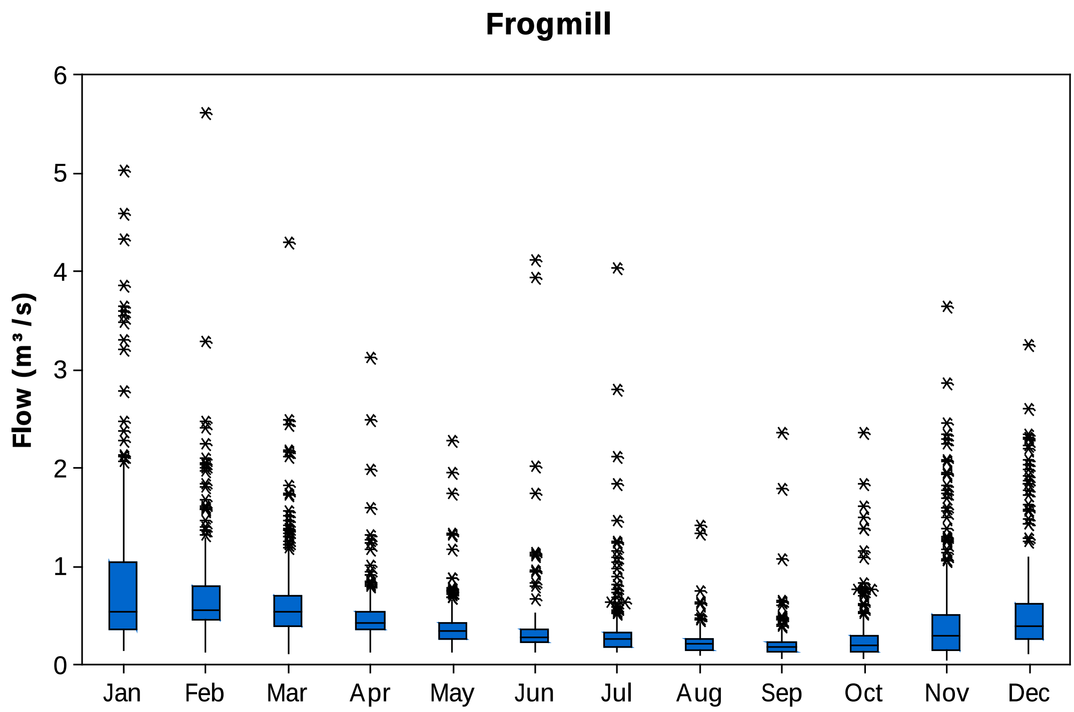


Figure VIII.7: Boxplots of the mean daily flow records from the Frogmill gauging station on River Hamble

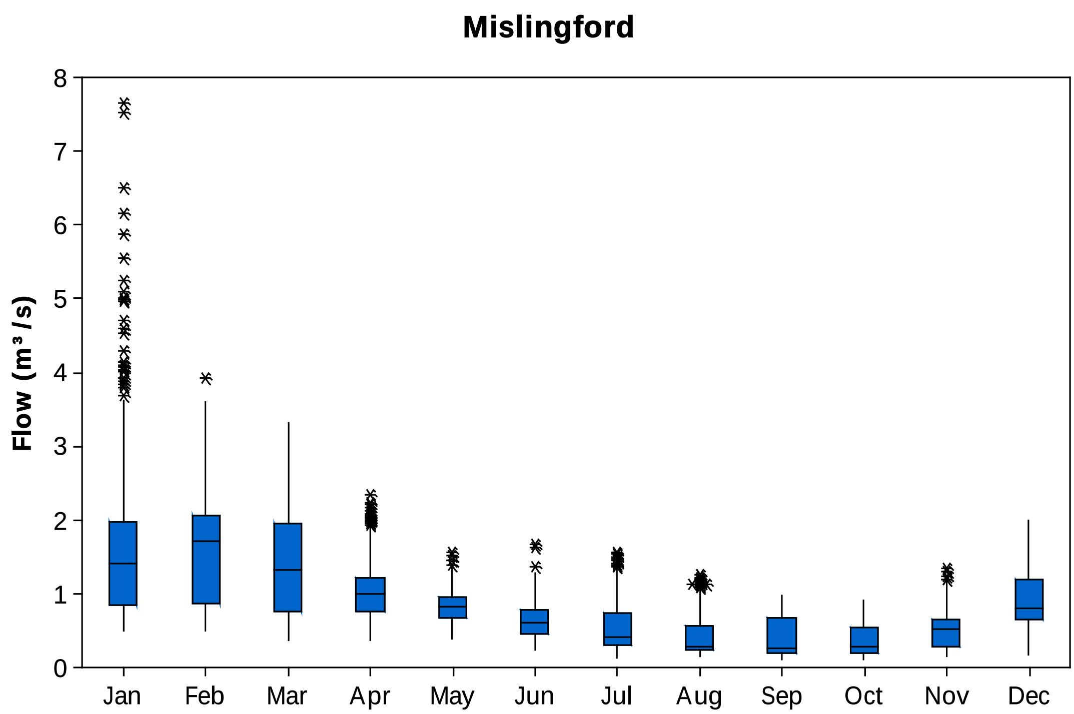


Figure VIII.8: Boxplots of the mean daily flow records from the Mislingford gauging station on River Meon

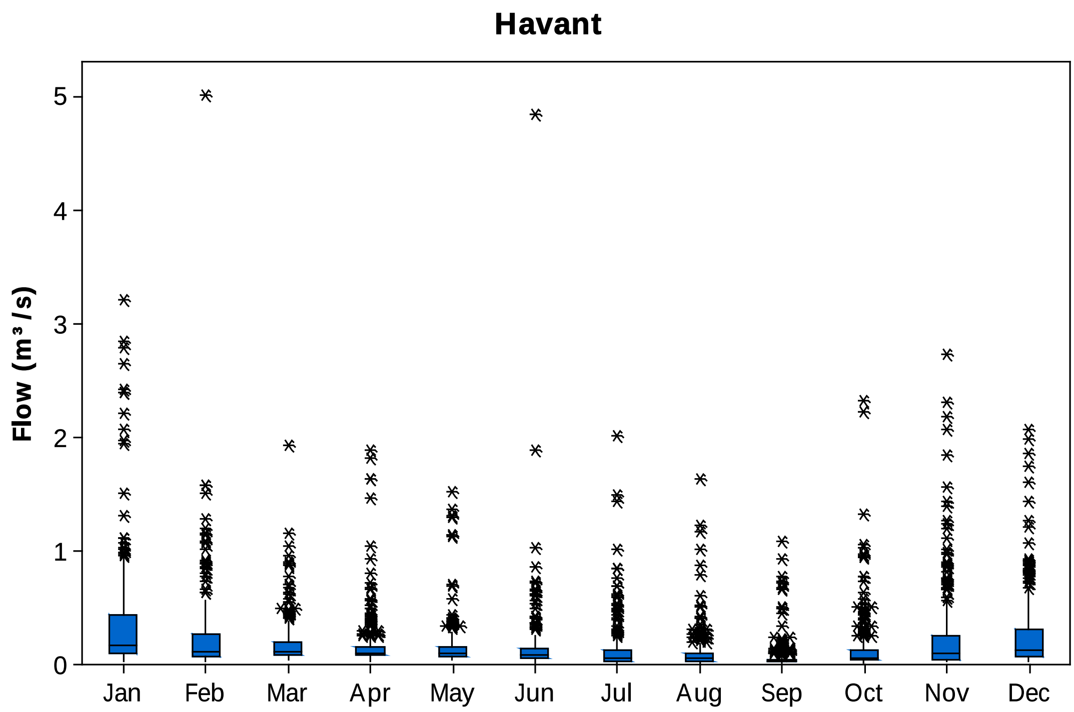


Figure VIII.9: Boxplots of the mean daily flow records from the Havant gauging station on Hermitage Stream

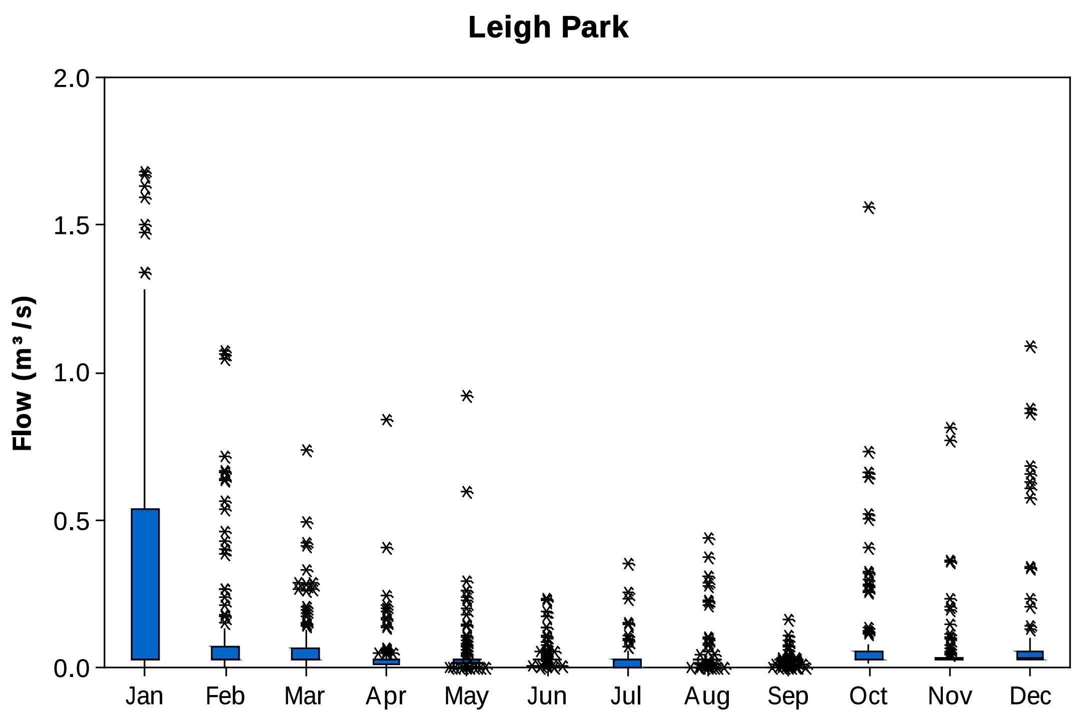


Figure VIII.10: Boxplots of the mean daily flow records from the Leigh Park gauging station on Lavant Stream

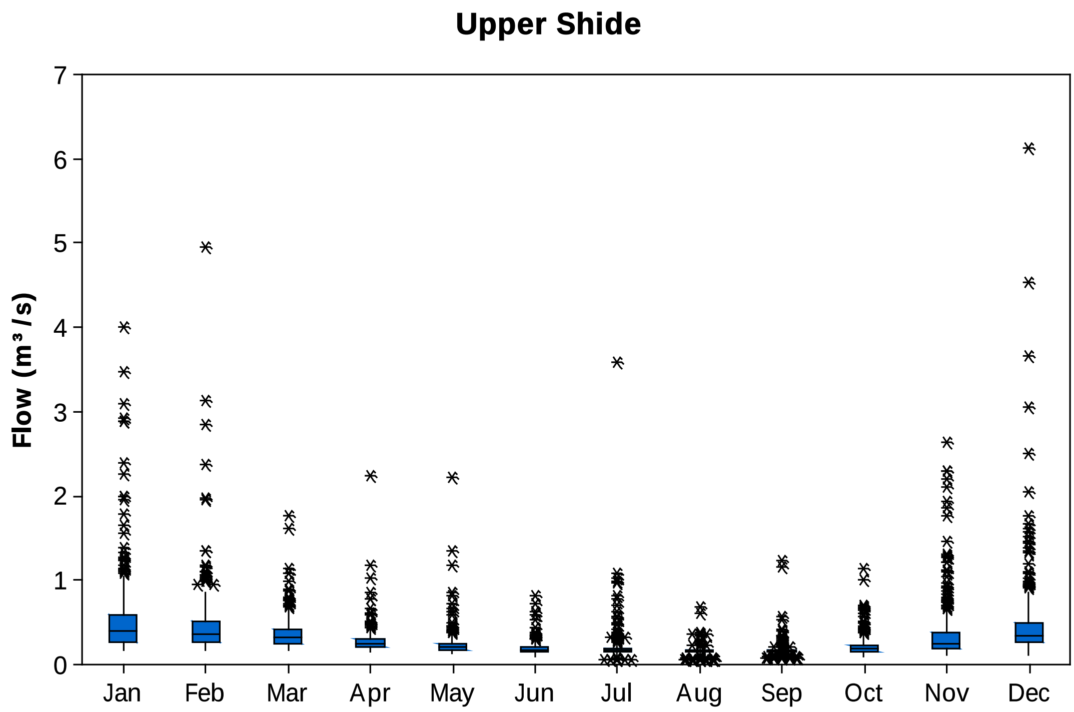


Figure VIII.11: Boxplots of the mean daily flow records from the Upper Shide gauging station on River Medina

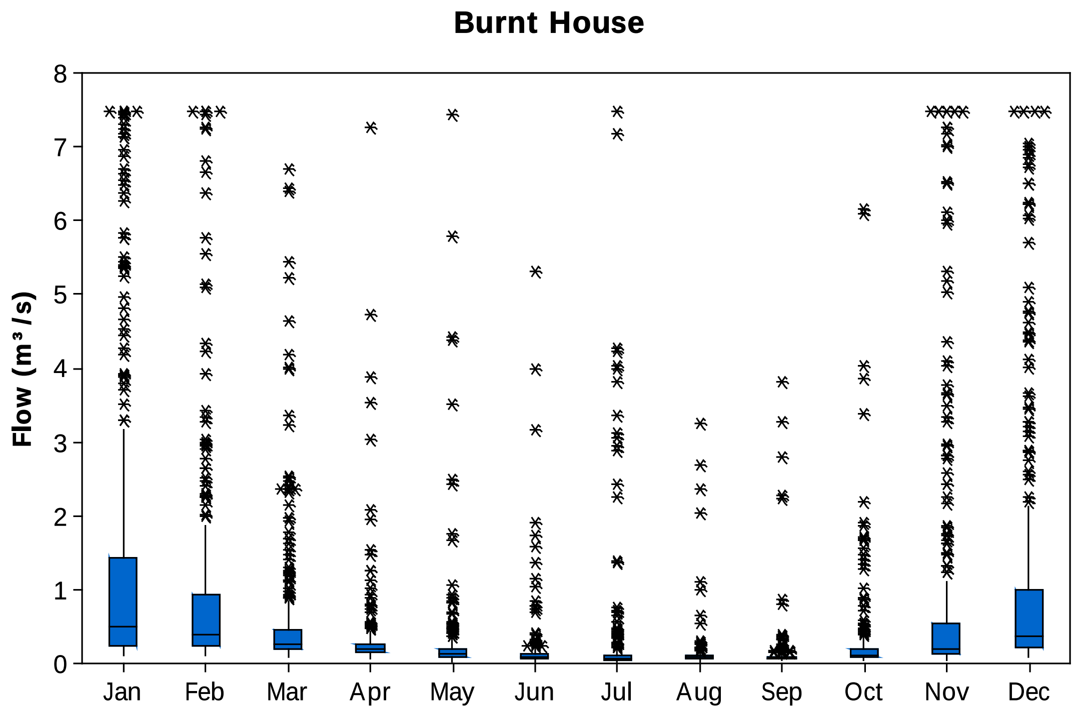


Figure VIII.12: Boxplots of the mean daily flow records from the Burnt House gauging station on Eastern Yar

In general, flows were highest in the colder months. However flows were highly variable in some of the water courses, particularly those with lower average flow rates. This indicates that flow from smaller inputs is less predictable throughout the year. On the other hand, flow at Broadlands, Riverside Park and Mislingford (located on Rivers Test, Itchen and Meon respectively) had relatively low intra-month variability. All three of these rivers originate in the chalk lands to the north of the catchment so are groundwater fed. Flow rates of rivers in permeable bedrock tend to respond more slowly to rainfall due to the long residence time of water in aquifers, while flow rates in rivers on low permeability bed rock tend to respond quickly to rainfall due to high run off.

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

During the shoreline survey watercourses which could be safely accessed were measured and sampled allowing spot estimates of the *E. coli* loading they were generating to be made. Coverage varied and some areas could not be surveyed for reasons of safe and legal access. The larger rivers encountered could not generally be measured for safety reasons.

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

Number	Date & Time	NGR	*E. coli* (cfu/100ml)	Flow (m^3/day)	*E. coli* loading (cfu/day)
1	29/01/2013 14:27	SZ 43213 98685	380	2709.9	1.03×10^{10}
2	30/01/2013 10:03	SZ 58630 98772	4000	121888.8	4.88×10^{12}
3	29/01/2013 10:09	SZ 41162 91185	600	5815.8	3.49×10^{10}
4	29/01/2013 10:14	SZ 41151 91224	600	2269.3	1.36×10^{10}
5	29/01/2013 10:20	SZ 41166 91347	560	870.9	4.88×10^{9}
6	29/01/2013 10:34	SZ 40895 91829	1200	9227.5	1.11×10^{11}
7	29/01/2013 11:54	SZ 37484 90113	1600	1437.3	2.30×10^{10}
8	30/01/2013 10:06	SZ 47727 95904	220000	10152.3	2.23×10^{13}
9	30/01/2013 10:36	SZ 47108 95342	3300	101751.6	3.36×10^{12}
10	30/01/2013 11:27	SZ 46173 93997	720	2073.3	1.49×10^{10}
11	30/01/2013 11:31	SZ 46171 93974	720	703	5.06×10^{9}
12	30/01/2013 11:34	SZ 46133 93908	280000	1223.4	3.43×10^{12}
13	30/01/2013 11:42	SZ 45967 93704	910	59947.8	5.46×10^{11}
14	30/01/2013 12:00	SZ 45634 93419	650	51757.1	3.36×10^{11}
15	29/01/2013 00:00	SZ 57764 92823	7500	18740.2	1.41×10^{12}

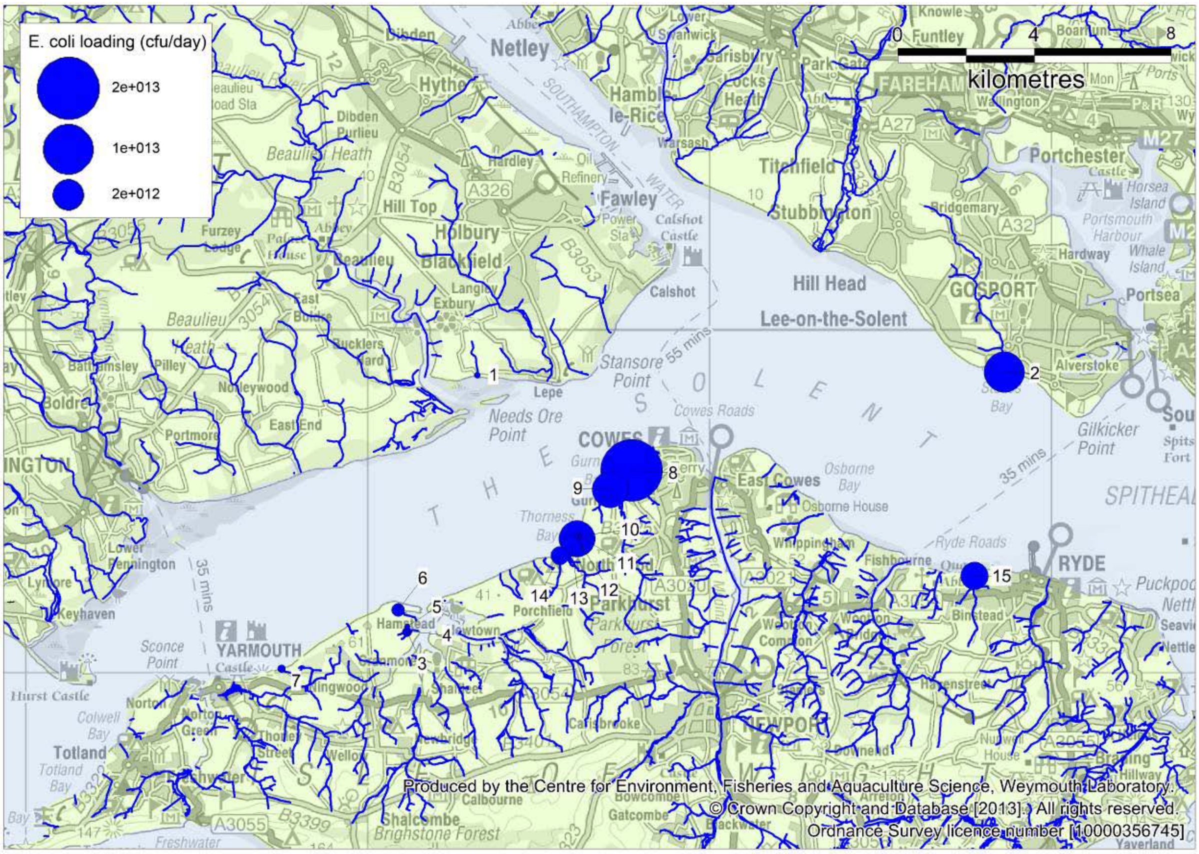


Figure VIII.13 Measured stream loadings from shoreline survey

Figure VIII.13 shows the *E. coli* loadings measured during the survey. There were several small streams which discharged from the north shore of the Isle of Wight. The most contaminated stream discharged at Thorness Bay on the Isle of Wight (12). However, the higher flow from the stream at point 8 near Cowes combined with its high *E. coli* concentration meant that this had the highest *E. coli* loading. There were no significant minor streams discharging from the New Forest, but the Alver River on the eastern end of the mainland stretch of the Solent contributed approximately 4.88×10^{12} *E. coli* per day and is therefore a potentially significant source of contamination.

APPENDIX IX
HYDROGRAPHY

BATHYMETRY

The Solent is a large, semi enclosed water body which is bordered by the Isle of Wight (to the south) and the south coast of England (to the north) and is open to the English Channel at either end. It is approximately 32km in length, east to west and is about 3-5km in width. It is characterised by a wide central channel which is generally between 12 and 25m in depth relative to chart datum (CD) flanked by gently sloping subtidal and intertidal areas of varying width. A narrow and relatively deep entrance (1.3km wide and 40m below CD) exists in the west between Hurst Spit and Fort Albert where accelerated tidal streams are likely to promote turbulent mixing. Along the north western shore the intertidal gradually slopes south towards the main channel. The south western shore, on the Isle of Wight is enclosed by cliffs and displays a much steeper gradient, with a much smaller intertidal area. The Medina estuary marks the boundary between the West and East Solent and it is also here that Southampton Water adjoins the East Solent through the deepwater Thorn channel. The Thorn Channel is displaced by the Bramble Sand Bank situated at the mouth of Southampton Water and displays a north east to south west orientation. The East Solent extends to Gilkicker Point on the English coast and Nettlestone Point on the Isle of Wight, and its entrance here is much wider (approximately 5km) compared to the West Solent. The north east shore on the Isle of Wight displays a more gradual sloping, gradient northwards towards the deepwater channel and sandy beaches are exposed on a low tide. In comparison at Gilkicker Point the gradient is steep and comprises of a much smaller intertidal area. Within the East Solent deepwater channel there are a couple of raised banks, Ryde Middle situated north of Wooton Creek and Mother Bank Spit and Sturbridge Shoal situated south of Gilkicker Point. The main shipping channels within the Solent are regularly dredged in order to maintain their depths (Hampshire County Council, 2010). The substrate in the main Solent channel is predominantly sand and gravel (Hampshire County Council, 2010 & Futurecoast, 2002), with sand, gravel and mud in the intertidal and nearshore regions.

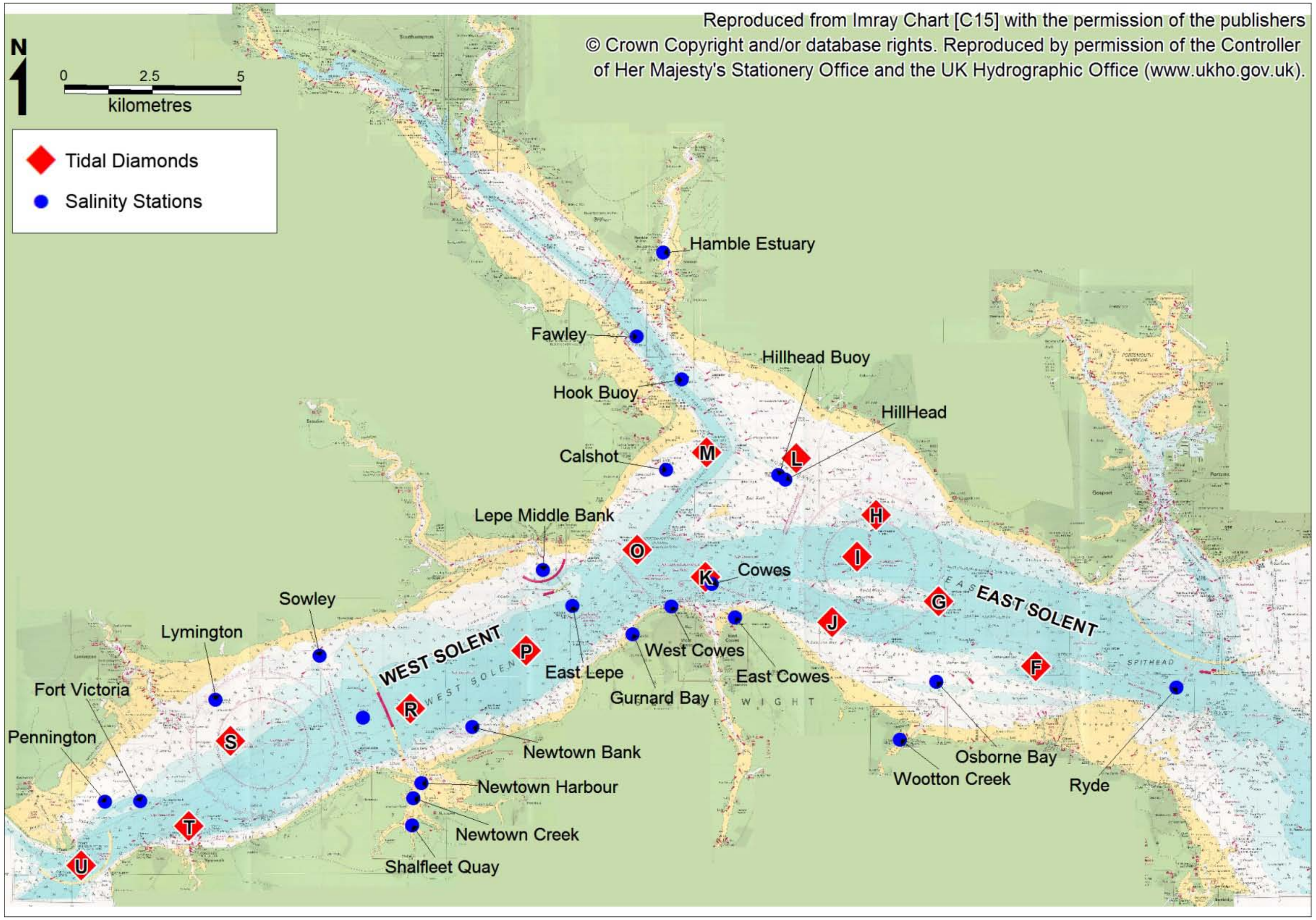


Figure IX.1 Bathymetry chart of the Solent

ADJOINING ESTUARIES

There are several separately defined estuaries which drain into the Solent. Seven of these drain directly to the survey area, and their characteristics are presented in Table IX.1.

Table IX.1. Characteristics of the Solent Estuaries

Estuary	Area km²	% Intertidal area	Channel Length (km)	Flow Ratio Mean	Flow Ratio Max
Southampton Water	39.8	35	20.2	0.008	0.015
Beaulieu River	5.5	76	10.4	-	-
Newtown Creek	3.3	89	3.3	-	-
Lymington	2.4	79	2.5	0.018	0.276
Medina	2.2	46	7.4	0.002	0.036
Western Yar	1.1	88	3.2	-	-
Wootton Creek	1.0	93	2.6	-	-

Data from Futurecoast, 2002

As these estuaries are enclosed and they receive contamination from various sources levels of faecal indicator bacteria within them are likely to be higher than within the Solent as a whole. Their shape and size will influence the extent to which these indicators will be diluted and die off before being carried out into the Solent. All the main estuaries are of sufficient size relative to river inputs that they will only discharge to the Solent as the tide ebbs, whereas other smaller watercourses with no estuary will flow into the Solent continuously. As a result, the plumes from these estuaries will only impact along the path followed by the ebb tide, whereas plumes from smaller watercourses discharging directly into the Solent will impact along the paths of both the flood and ebb tide.

Southampton Water is by far the largest estuary discharging to the Solent. Flow ratios were available for Southampton Water, the Medina and the Lymington, and were low suggesting that these are partially to well mixed estuaries. However, maximum flow ratio for the Lymington suggests occasional stratification may occur at high river flows (Futurecoast, 2002). Higher flow ratios also indicate less dilution of land runoff before it is discharged to the Solent. For the remaining estuaries, river flow data was limited or not available but the observed river flows are relatively low and therefore it can be assumed that they are well mixed with a well diluted plume. An exception to this is the Beaulieu River where the river flow is variable and a plume has been observed at high river flow on an ebb tide (Futurecoast, 2002). The River Meon is a watercourse of similar size to the Beaulieu and Lymington but does not have an estuary and flows directly into the Solent after passing through a dammed wetland.

WATER CIRCULATION PATTERNS

Currents in coastal waters are predominantly driven by a combination of tide, wind and freshwater inputs. Tidal amplitude is large, and tidal streams are likely to dominate patterns of water circulation in the area under most conditions. The Solent estuary is predominantly macro-tidal, and exhibits a complex tidal regime with tidal stand still and double high waters experienced at several locations (Natural England, 2010). The highest tidal range is observed at Ryde; 3.8m on spring tides and 1.9m on neap tides (Table IX.2). The smallest tidal range is observed at Hurst Point (the most western point of the Solent survey area) with 2.0m on springs and 0.9m on neaps.

Table IX.2 Tide levels and ranges within the Solent

	Height (m) above Chart Datum				Range (m)	
Port	MHWS	MHWN	MLWN	MLWS	Springs	Neaps
Hurst Point	2.7	2.3	1.4	0.7	2.0	0.9
Stansore Point	4.0	3.3	1.6	0.5	3.5	1.7
Cowes	4.2	3.5	1.8	0.8	3.4	1.7
Ryde	4.6	3.8	1.9	0.8	3.8	1.9

Data from the Admiralty Total Tide

Table IX.3 presents the direction and rate of tidal streams at 15 stations in the Solent on spring and neap tides at hourly intervals before and after high water. The locations of these stations are shown in Figure IX.1. Figures IX.2 to IX.4 present modelled tidal streams at a variety of states of the tide.

In the English Channel tidal streams flood parallel to the coast in an easterly direction, and the reverse occurs on the ebb. The Isle of Wight and the constricted opening to the western Solent at Hurst Spit divert flood streams in a north easterly direction into the Solent. The tidal streams run parallel to the shores between the Isle of Wight and England. North of the Medina the tidal stream splits, with the largest proportion flowing south-east towards the eastern entrance and a small proportion flowing north into Southampton Water through the Thorn channel. Tidal flows will also be redirected around the raised Bramble sand bank located on the southeast of the mouth of Southampton water and rejoin with the main eastern Solent Channel. The opposite occurs on an ebb tide (Figure IX.2 and IX.3). Due to the complexity of the Solent's tidal regime, tidal streams do not change direction until two or three hours after high and low water (Figure IX.4).

Tides are asymmetrical, with a shorter duration and faster moving ebb tide. Current velocities are around 50% smaller on neap tides. The tidal diamonds indicate that the tidal excursion (the distance water travels during the course of a flood or ebb tide) differs within the Solent, the largest tidal excursions are experienced in the western Solent where the currents are stronger, an average of 21km on spring tides and 10km on neap tides is experienced. In the eastern Solent the tidal excursion averages 14km on spring tides, and 7km on neap tides (Table IX.3). There is a considerable difference in the current velocities and tidal excursions between the east and west Solent. Although the east Solent experiences slacker tides they are still sizeable with current velocities reaching 1.95 m/s at Station K (north of the mouth of the Medina) and 1.23 m/s at Stations I and J (north of Ryde). Station U situated at Hurst spit on the western entrance experiences the strongest tidal streams within the Solent (2.26 m/s). Stronger currents in the Western Solent are a consequence of the large hydraulic gradient between the eastern and western boundaries, whereby there is a large difference between the high waters at Hurst Point and Calshot (New Forest District Council, 2010). Currents also tend to be considerably stronger in the deeper waters of the central channel compared to the nearshore and intertidal areas.

Advection of pollutants by tidal currents is likely to be the main mode of contaminant transport in the Solent. The flood tide will convey relatively clean water originating from the open English Channel into the western Solent which is transported east. Contamination from shoreline sources will tend to travel along the shore to which it is discharged, becoming progressively more diluted with time. On an ebb tide flows from the estuaries surrounding the Solent discharge into the Solent and their tidal plumes will be carried west with the predominant ebb flows. Due to the higher current velocities and tidal excursion in the west Solent, any potential contaminated water plume will travel around 70% further than in the east Solent. However some watercourses do not flow into an estuary they flow straight across the beach into the Solent, such as the River Meon in the eastern Solent. These watercourses are likely to carry microbiological contamination and will flow continually irrespective of whether it is a flood or ebb tide.

Table IX.3 Tidal Stream predictions for the Solent (locations of Stations shown in Figure IX.1)

	Time before /after Highwater	Station F			Station G			Station H			Station I		
		Direction (°)	Rate (m/s) Spring	Neap	Direction (°)	Rate (m/s) Spring	Neap	Direction (°)	Rate (m/s) Spring	Neap	Direction	Rate (m/s) Spring	Neap
EASTERN SOLENT	HW-6	110	0.67	0.31	110	0.62	0.31	117	0.62	0.31	112	0.87	0.41
	HW-5	115	0.77	0.36	116	0.87	0.46	119	0.82	0.41	106	1.03	0.51
	HW-4	118	0.57	0.31	126	0.87	0.46	111	0.62	0.31	100	0.98	0.51
	HW-3	120	0.15	0.10	134	0.57	0.31	96	0.10	0.05	96	0.72	0.36
	HW-2	249	0.05	0.05	216	0.10	0.05	305	0.26	0.15	86	0.21	0.10
	HW-1	282	0.41	0.21	289	0.46	0.26	298	0.51	0.26	286	0.31	0.15
	HW	289	0.77	0.36	295	0.77	0.36	294	0.77	0.41	283	0.82	0.41
	HW+1	286	0.87	0.41	297	1.03	0.51	291	0.98	0.51	285	1.18	0.62
	HW+2	286	0.51	0.26	293	0.82	0.41	295	0.57	0.31	287	1.23	0.62
	HW+3	8	0.10	0.05	325	0.15	0.10	125	0.21	0.10	286	0.72	0.36
	HW+4	75	0.21	0.10	70	0.21	0.10	118	0.36	0.15	270	0.21	0.10
	HW+5	96	0.36	0.21	91	0.26	0.15	117	0.41	0.21	120	0.31	0.15
	HW+6	107	0.57	0.31	106	0.51	0.26	117	0.51	0.26	113	0.72	0.36
	Excursion (flood)		11.84	6.11		14.06	7.40		13.14	6.48		17.39	8.70
	Excursion (ebb)		9.44	4.63		12.03	6.11		11.10	5.92		16.10	8.14

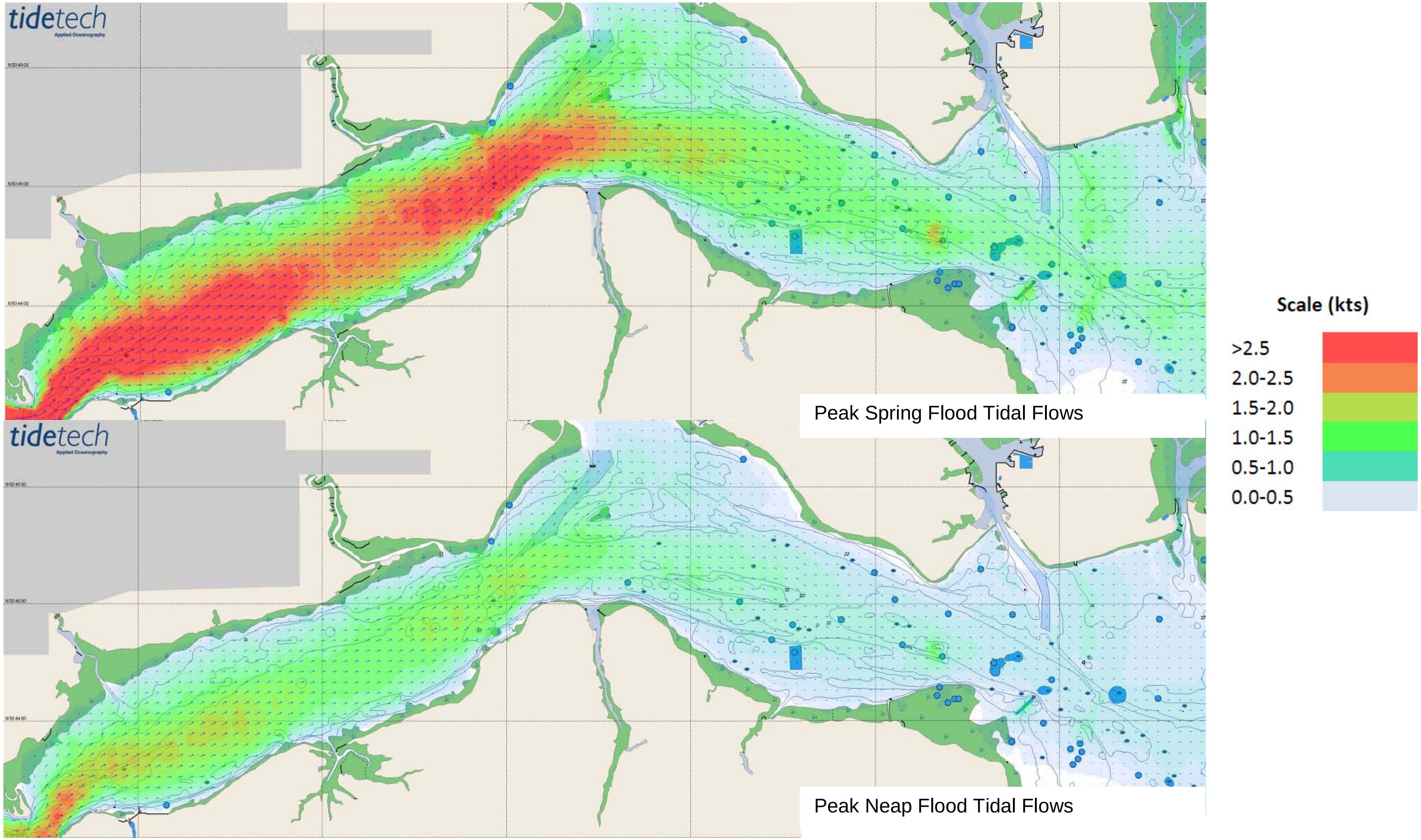
	Time before /after Highwater	Station J			Station K			Station L			Station M		
		Direction (°)	Rate (m/s) Spring	Neap	Direction (°)	Rate (m/s) Spring	Neap	Direction (°)	Rate (m/s) Spring	Neap	Direction (°)	Rate (m/s) Spring	Neap
EASTERN SOLENT	HW-6	119	0.67	0.31	84	1.29	0.62	110	0.36	0.21	22	0.93	0.46
	HW-5	116	0.98	0.51	90	1.39	0.67	101	0.57	0.26	38	0.51	0.26
	HW-4	115	1.03	0.51	91	1.39	0.72	100	0.57	0.26	70	0.21	0.10
	HW-3	116	0.62	0.31	90	1.13	0.57	93	0.21	0.10	58	0.21	0.10
	HW-2	124	0.15	0.10	96	0.46	0.21	303	0.15	0.05	19	0.72	0.36
	HW-1	285	0.36	0.15	259	0.36	0.15	296	0.51	0.26	8	0.26	0.10
	HW	294	0.93	0.46	267	1.44	0.72	293	0.67	0.26	232	0.51	0.26
	HW+1	293	1.23	0.62	268	1.95	0.98	290	0.62	0.31	230	0.57	0.26
	HW+2	295	0.93	0.46	269	1.54	0.77	283	0.41	0.31	226	0.62	0.31
	HW+3	317	0.31	0.15	269	0.93	0.46	191	0.21	0.21	205	0.72	0.36
	HW+4	-	-	-	275	0.26	0.10	139	0.41	0.10	180	1.23	0.62
	HW+5	115	0.21	0.10	83	0.41	0.21	107	0.21	0.21	70	0.10	0.05
	HW+6	120	0.51	0.26	84	1.03	0.51	105	0.26	0.10	25	0.82	0.41
	Excursion (flood)		14.99	7.59		25.54	12.58		9.25	4.44		13.51	6.66
	Excursion (ebb)		13.51	6.67		23.32	12.47		9.25	7.96		13.14	6.48

WESTERN SOLENT

Time before /after Highwater	Station N			Station O			Station P			Station R		
	Direction (°)	Rate (m/s)		Direction (°)	Rate (m/s)		Direction (°)	Rate (m/s)		Direction (°)	Rate (m/s)	
		Spring	Neap		Spring	Neap		Spring	Neap		Spring	Neap
HW-6	323	0.31	0.21	52	1.03	0.51	65	1.49	0.72	70	1.29	0.62
HW-5	330	0.26	0.15	54	1.08	0.57	64	1.75	0.87	70	1.54	0.77
HW-4	338	0.05	0.05	55	1.03	0.51	66	1.70	0.87	69	1.49	0.77
HW-3	324	0.21	0.10	51	0.82	0.41	62	1.49	0.77	68	1.13	0.57
HW-2	322	0.51	0.31	43	0.51	0.26	60	0.87	0.41	66	0.62	0.31
HW-1	316	0.31	0.15	253	0.10	0.05	255	0.21	0.10	-	-	-
HW	135	0.05	0.00	234	1.08	0.51	245	1.49	0.77	248	0.72	0.36
HW+1	-	-	-	234	1.34	0.67	244	1.80	0.93	251	1.29	0.62
HW+2	121	0.15	0.10	234	1.18	0.57	244	1.70	0.82	255	1.64	0.82
HW+3	140	0.46	0.31	230	0.93	0.46	246	1.54	0.77	254	1.59	0.77
HW+4	146	0.87	0.57	223	0.51	0.26	226	1.18	0.57	247	0.82	0.41
HW+5	147	0.21	0.10	72	0.21	0.10	84	0.10	0.05	66	0.15	0.05
HW+6	321	0.31	0.21	53	0.87	0.46	66	1.34	0.67	71	1.13	0.57
Excursion (flood)		7.03	4.26		19.98	10.18		31.46	15.73		26.46	13.14
Excursion (ebb)		6.29	3.89		18.50	9.07		28.50	14.25		21.83	10.73

WESTERN SOLENT

Time before /after Highwater	Station S			Station T			Station U		
	Direction (°)	Rate (m/s)		Direction (°)	Rate (m/s)		Direction (°)	Rate (m/s)	
		Spring	Neap		Spring	Neap		Spring	Neap
HW-6	53	1.13	0.57	82	1.23	0.62	49	1.90	0.98
HW-5	53	1.13	0.57	82	1.23	0.62	53	2.00	0.98
HW-4	54	1.13	0.57	82	1.13	0.57	55	1.80	0.93
HW-3	55	0.93	0.46	84	0.98	0.46	57	1.80	0.87
HW-2	57	0.41	0.21	87	0.51	0.26	64	1.29	0.62
HW-1	240	0.46	0.21	235	0.15	0.05	263	0.10	0.05
HW	235	1.23	0.62	261	0.87	0.41	235	1.44	0.72
HW+1	235	1.29	0.62	264	1.39	0.72	233	2.06	1.03
HW+2	234	1.29	0.62	265	1.44	0.72	232	2.26	1.13
HW+3	232	1.13	0.57	265	1.29	0.62	234	2.26	1.13
HW+4	224	0.46	0.21	266	1.03	0.51	238	1.13	0.57
HW+5	55	0.51	0.26	90	0.15	0.10	52	0.41	0.21
HW+6	52	1.13	0.57	82	1.03	0.51	47	1.70	0.82
Excursion (flood)		22.94	11.47		22.57	11.29		39.23	19.43
Excursion (ebb)		21.09	10.18		22.20	10.92		33.31	16.65



FigureIX.2 ***Modified images of modelled peak current velocity and direction of tidal streams on Spring and Neap Flood tides within the Solent***
(Produced by tidetech using Expediton Software [www.expeditionmarine.com], 2012)

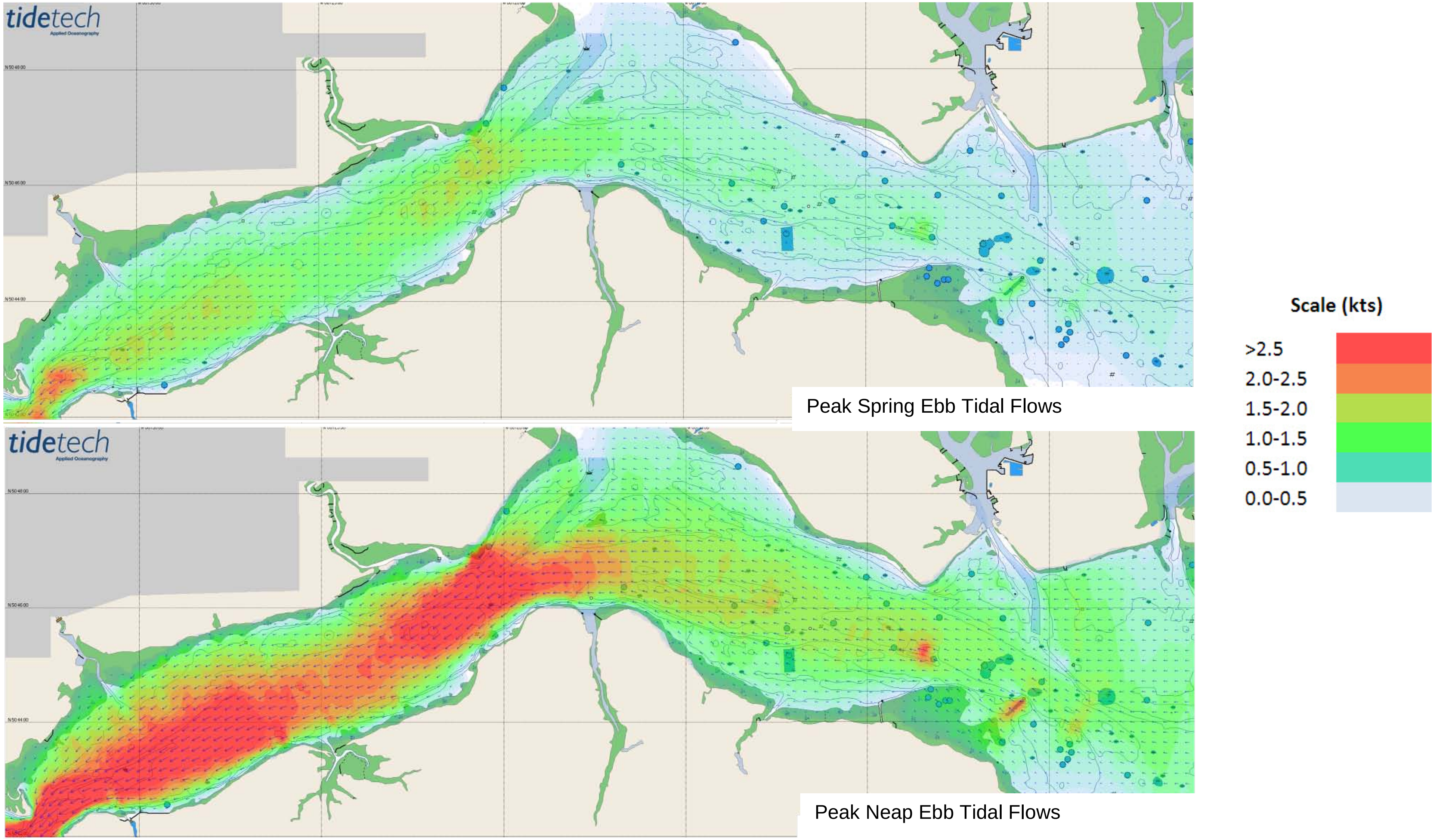


Figure IX.3 ***Modified images of modelled peak current velocity and direction of tidal streams on Spring and Neap Ebb tides within the Solent***
(Produced by tidetech using Expediton Software [www.expeditionmarine.com], 2012)

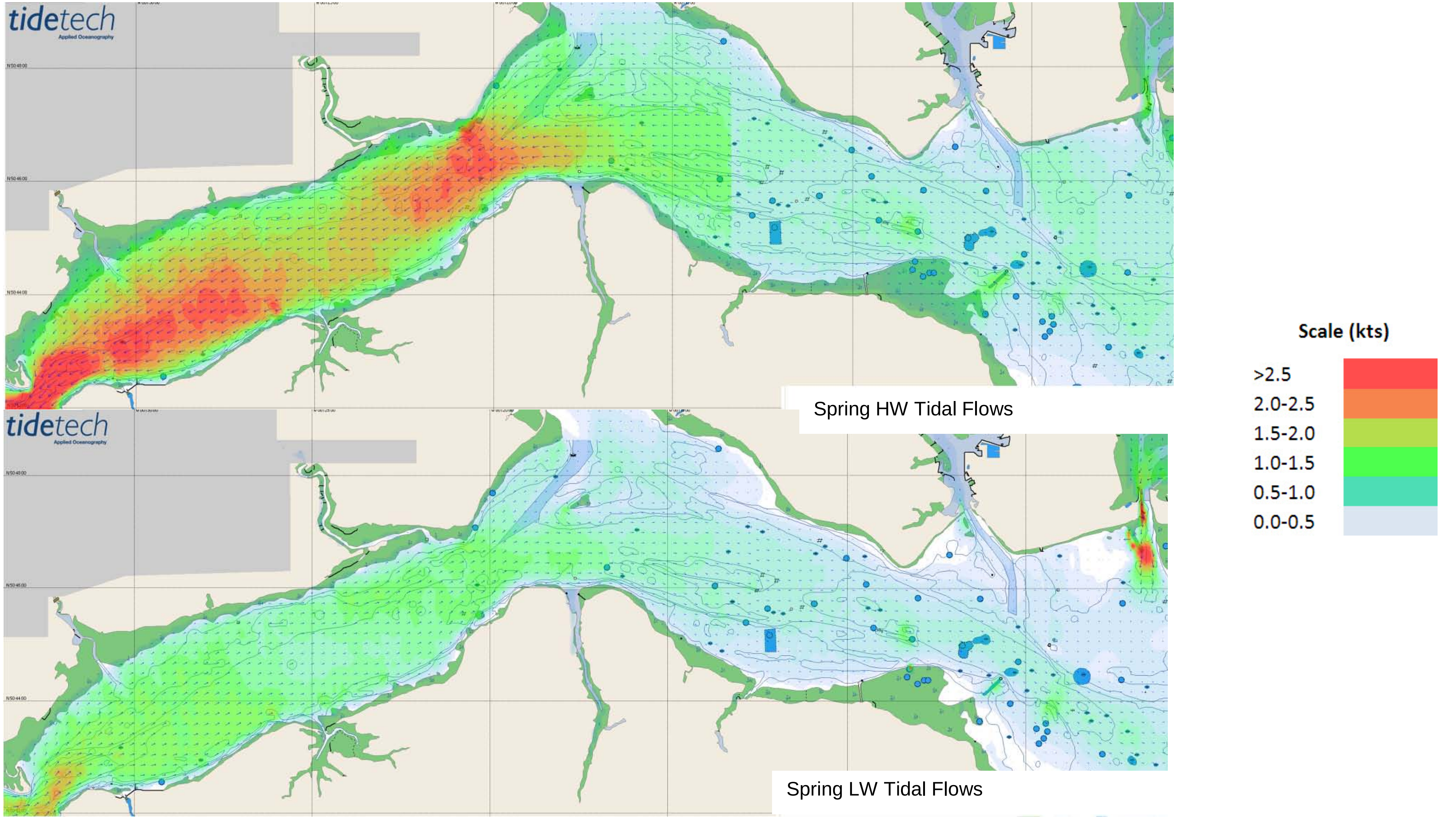


Figure IX. 4. ***Modified images of modelled peak current velocity and direction of tidal streams on Spring HW and LW within the Solent***
(Produced by tidetech using Expediton Software [www.expeditionmarine.com], 2012)

In addition to tidally driven currents are the effects of freshwater inputs and wind. The flow ratio of the Solent as a whole (freshwater input:tidal exchange) is low and the system is predominantly well mixed. Density driven circulation is unlikely to modify tidal circulation. There may be some density driven circulation within the adjoining estuaries at times, although this is unlikely to affect circulation within the Solent. One density effect of potential significance is that sewage effluent discharged from long sea outfalls in deeper water, such as the Budds Farm outfall will be less dense than the surrounding seawater and so will float up and away from benthic shellfish stocks.

Salinity measurements taken between 2002 and 2012 at 24 points within the Solent and its major inlets (Figure IX.1) indicate average salinities approaching that of full strength seawater throughout. Lower salinities were observed in estuarine regions, especially Shalfeet Quay, situated in the upper reaches of the Newtown Creek (Figure IX.5). At the mouth of Newtown Creek salinities were consistently approaching that of full strength seawater indicating that significant dilution and mixing occurs before the waters of this estuary are discharged into the Solent. Slightly lower average salinities were recorded at stations located in the mouth of Southampton Water, suggesting a slightly higher freshwater influence here. Salinity at stations around the mouth of Southampton Water were negatively correlated with concentrations of faecal indicator organisms (Appendix X).

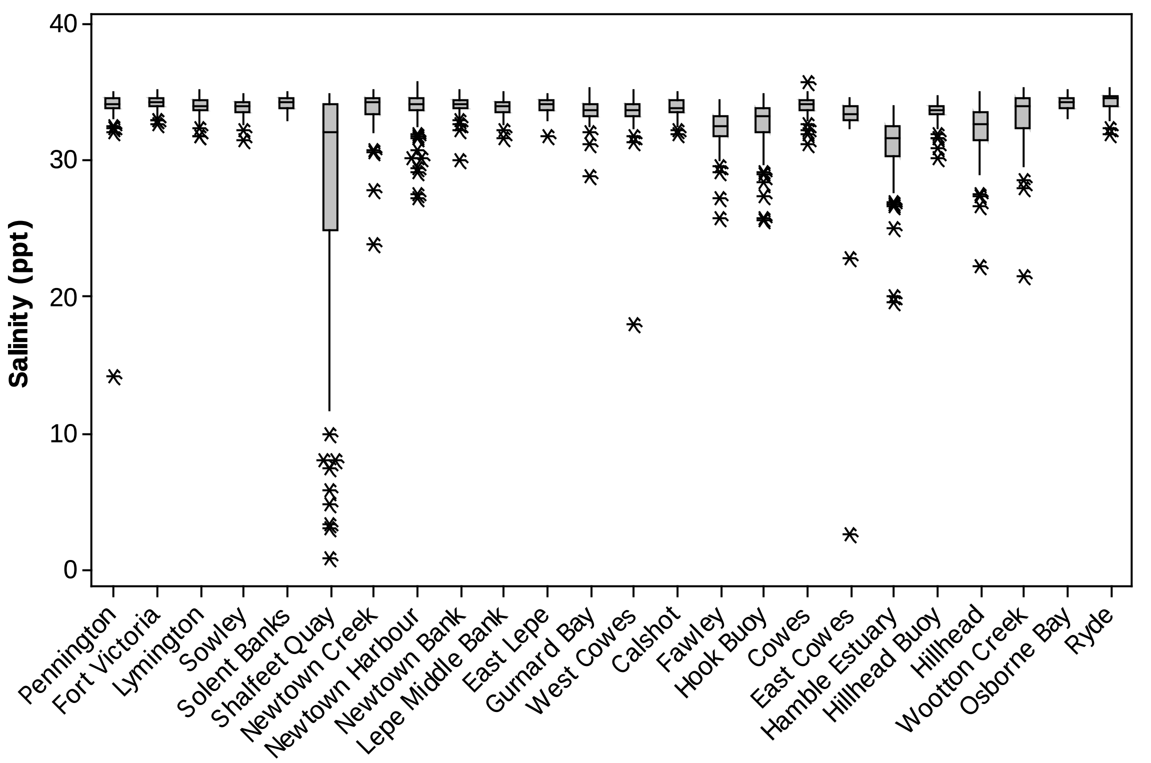


Figure IX.5 Boxplot of salinity readings take from the Solent (2002 – 2012)
Data from the Environment Agency

Strong winds will modify surface currents. Winds typically drive surface water at about 3% of the wind speed (Brown, 1991) so a gale force wind (34 knots or 17.2 m/s) would drive a surface water current of about 1 knot or 0.5 m/s. These currents in turn drive return currents which may travel lower in the water column or along sheltered margins. The prevailing south-westerly winds will tend to push surface water in a north-easterly direction. Exact effects are dependent on the wind speed and direction, as well as state of the tide and other environmental variables, so a great range of scenarios may arise. Where strong winds blow across a sufficient distance of water they may create wave action, and where these waves break contamination held in intertidal sediments may be re-suspended. However, there is limited wave action in the Solent because of the presence of the Isle of Wight and narrow entrance at Hurst Spit, which provide protection from the wind and offshore waves (New Forest District Council, 2010). It is therefore anticipated that re-suspension of sediments from breaking waves will be infrequent.

APPENDIX X
MICROBIOLOGICAL DATA: SEAWATER

BATHING WATERS

Due to changes in the analyses of bathing water quality by the Environment Agency from 2012, only data produced up to the end of 2011 was used in these analyses. It should be noted that the three main sewage discharges direct to the Solent were upgraded to provide UV treatment in March 2013. Therefore, the results presented in this report may not be fully representative of the current situation. There are 10 bathing waters in the Solent designated under the Directive 76/160/EEC (Council of the European Communities, 1975).

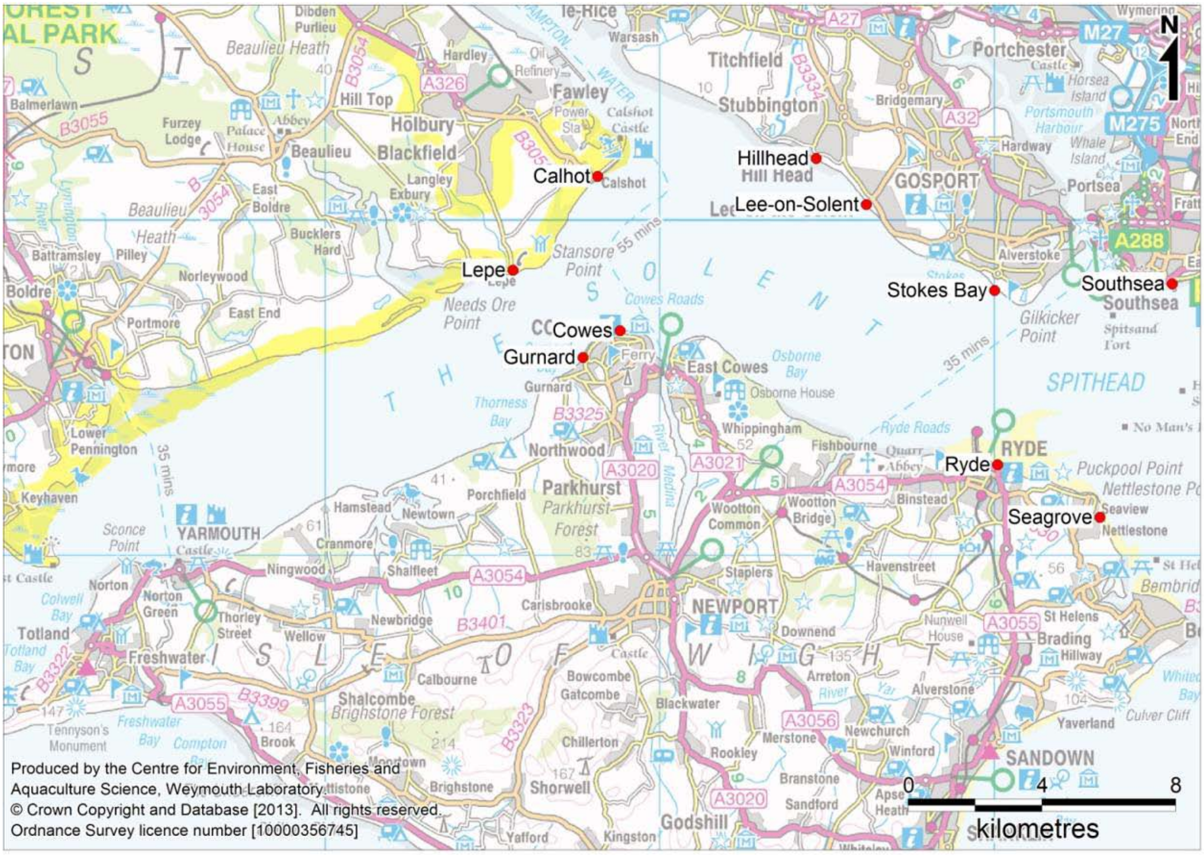


Figure X.1: Location of designated bathing waters monitoring points in the Solent.

Around twenty water samples were taken from each of the bathing waters sites during each bathing season, which runs from the 15th May to the 30th September. Samples were taken from the shore, and faecal coliforms were enumerated. Summary statistics of all results by bathing water are presented in Table X.1, and Figure X.2 presents box plots of these data.

Table X.1: Summary statistics for bathing waters faecal coliforms results, 2003-2011 (cfu/100ml).

Site	No.	Geo-mean	Min.	Max.	% exceeding 100 cfu/100ml	% exceeding 1000 cfu/100ml
Lepe	180	4.6	<2	346	3.9	0.0
Calshot	180	4.0	<2	960	5.0	0.0
Hillhead	180	9.0	<2	10000	12.8	1.7
Lee-on-Solent	179	4.6	<2	1200	3.9	0.6
Stokes Bay	180	5.3	<2	32900	5.6	0.6
Southsea	180	38.4	<2	2760	30.0	4.4
Gurnard	180	9.3	<2	1440	12.8	2.2
Cowes	180	8.5	<2	14000	12.2	2.2
Ryde	181	12.8	<2	1440	16.6	2.2
Seagrove	181	7.0	<2	3040	11.0	3.3

Data from the Environment Agency

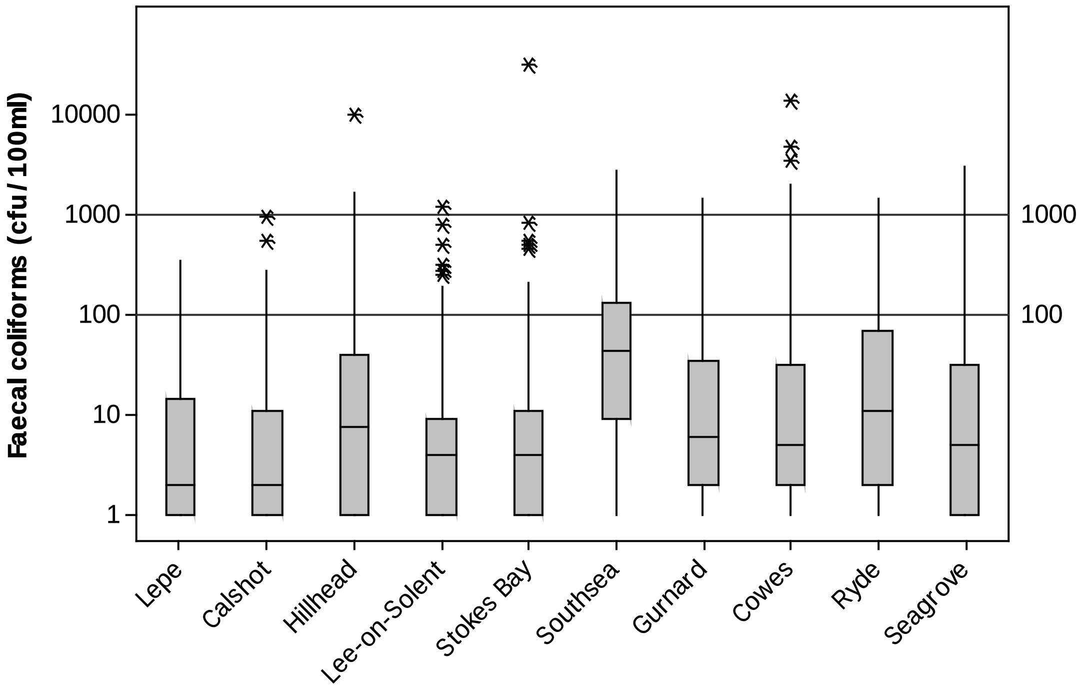


Figure X.2: Box-and-whisker plots of all faecal coliforms results by site
Data from the Environment Agency

Levels of contamination were broadly similar at all sites except Southsea, between Portsmouth and Langstone Harbours, where they were highest on average. Also, there were fewer very low results at Gurnard, Cowes and Ryde, on the north shore of the Isle of Wight. All sites had results exceeding 100 faecal coliforms/100 ml on at least 5 occasions. Only Lepe and Calshot did not have any results exceeding 1000 faecal coliforms/100 ml.

Comparisons of results from all 10 sites showed a significant difference between them (One-way ANOVA, p<0.001), indicating that there are spatial influences on the levels of faecal coliforms in the Solent. Results of post ANOVA tests (Tukeys comparison) are presented in Table X.2. Most notably, the results at Southsea were significantly higher than at all of the other sites.

Table X.2 Matrix to show results of post ANOVA Tukey tests of significance of differences (p<0.05 is significant) in faecal coliforms at bathing water sites. Grey boxes indicate that there is no significant difference; yellow boxes indicate that the site on the top side of the matrix has greater average results than the site on the left side of the matrix; green boxes indicate that the site on the top side of the matrix has lower average results than the site on the left side of the matrix.

	Lepe	Calshot	Hillhead	Lee-on-Solent	Stokes Bay	Southsea	Gurnard	Cowes	Ryde
Calshot									
Hillhead									
Lee-on-Solent									
Stokes Bay									
Southsea									
Gurnard									
Cowes									
Ryde									
Seagrove									

To investigate the effects of tidal state on faecal coliform results, circular-linear correlations were carried out against both the high/low and spring/neap tidal cycles for each of these bathing waters sampling points. Correlation coefficients are presented in Table X.3, with statistically significant correlations highlighted in yellow.

Table X.3: Circular linear correlation coefficients (r) and associated p values for faecal coliform results against the high low and spring/neap tidal cycles

		high/low		spring/neap	
Site	**n**	**r**	**p**	**r**	**p**
Lepe	180	0.375	<0.001	0.383	<0.001
Calshot	180	0.367	<0.001	0.354	<0.001
Hillhead	180	0.254	<0.001	0.23	<0.001
Lee-on-solent	179	0.151	0.018	0.193	0.001
Stokes Bay	180	0.189	0.002	0.129	0.053
Southsea	180	0.319	<0.001	0.184	0.003
Gurnard	180	0.238	<0.001	0.303	<0.001
Cowes	180	0.228	<0.001	0.241	<0.001
Ryde	181	0.39	<0.001	0.414	<0.001
Seagrove	181	0.446	<0.001	0.428	<0.001

Data from the Environment Agency

Results at all sites showed some correlation with tidal state on both tidal cycles, with the exception of Stokes Bay where the influence of the spring/neap cycle was not quite statistically significant. Figure X.3 presents polar plots of $\log_{10}$ faecal coliform results against tidal states on the high/low cycle for the correlations indicating a statistically significant effect. High water at Stansore Point is at 0° and low water is at 180°. Results of 100 faecal coliforms/100ml or less are plotted in green, those from 101 to 1000 are plotted in yellow, and those exceeding 1000 are plotted in red.

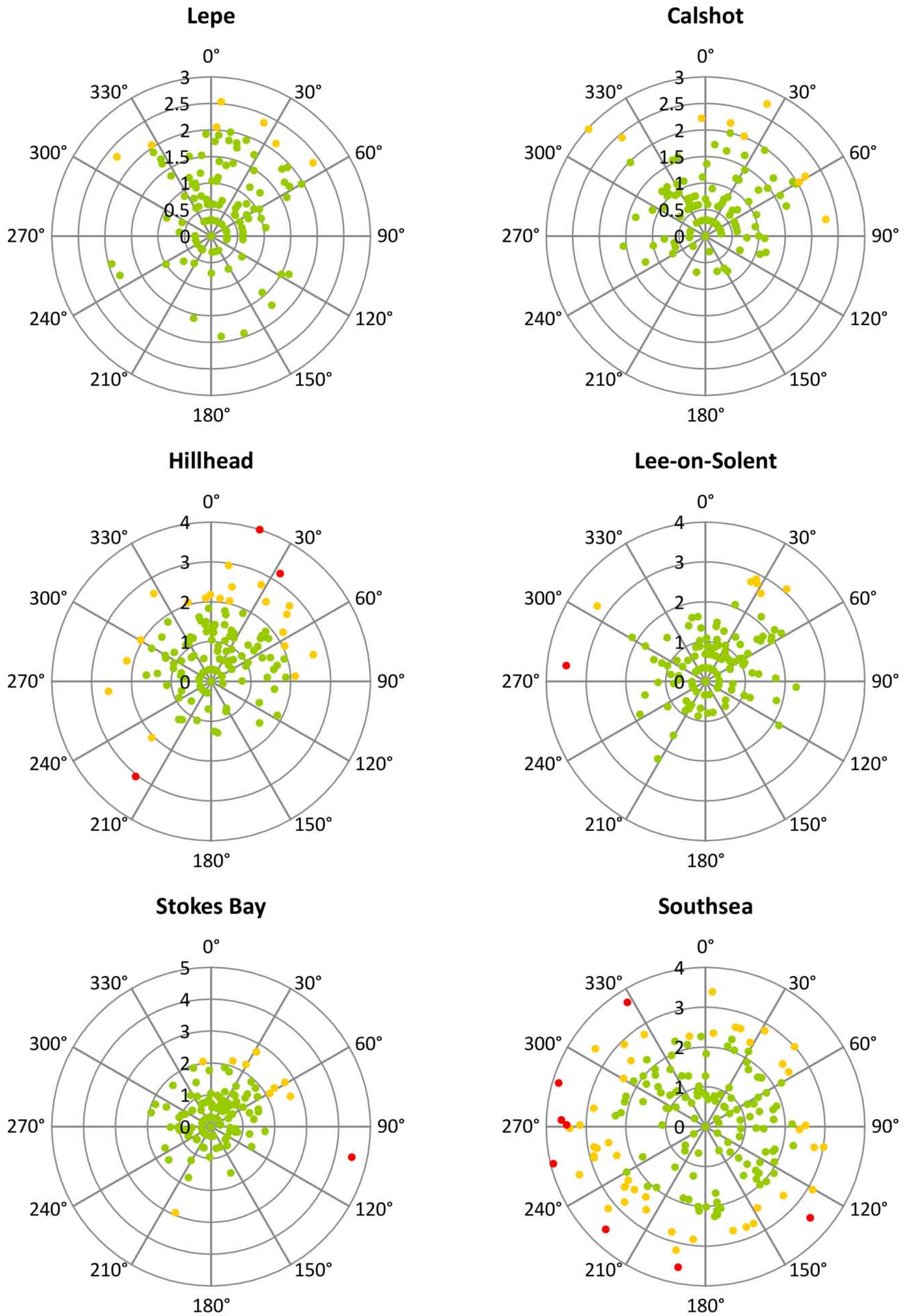


Figure X.3a: Polar plots of log$_{10}$ faecal coliforms against tidal state on the high/low tidal cycle for bathing waters monitoring points with significant correlations
Data from the Environment Agency

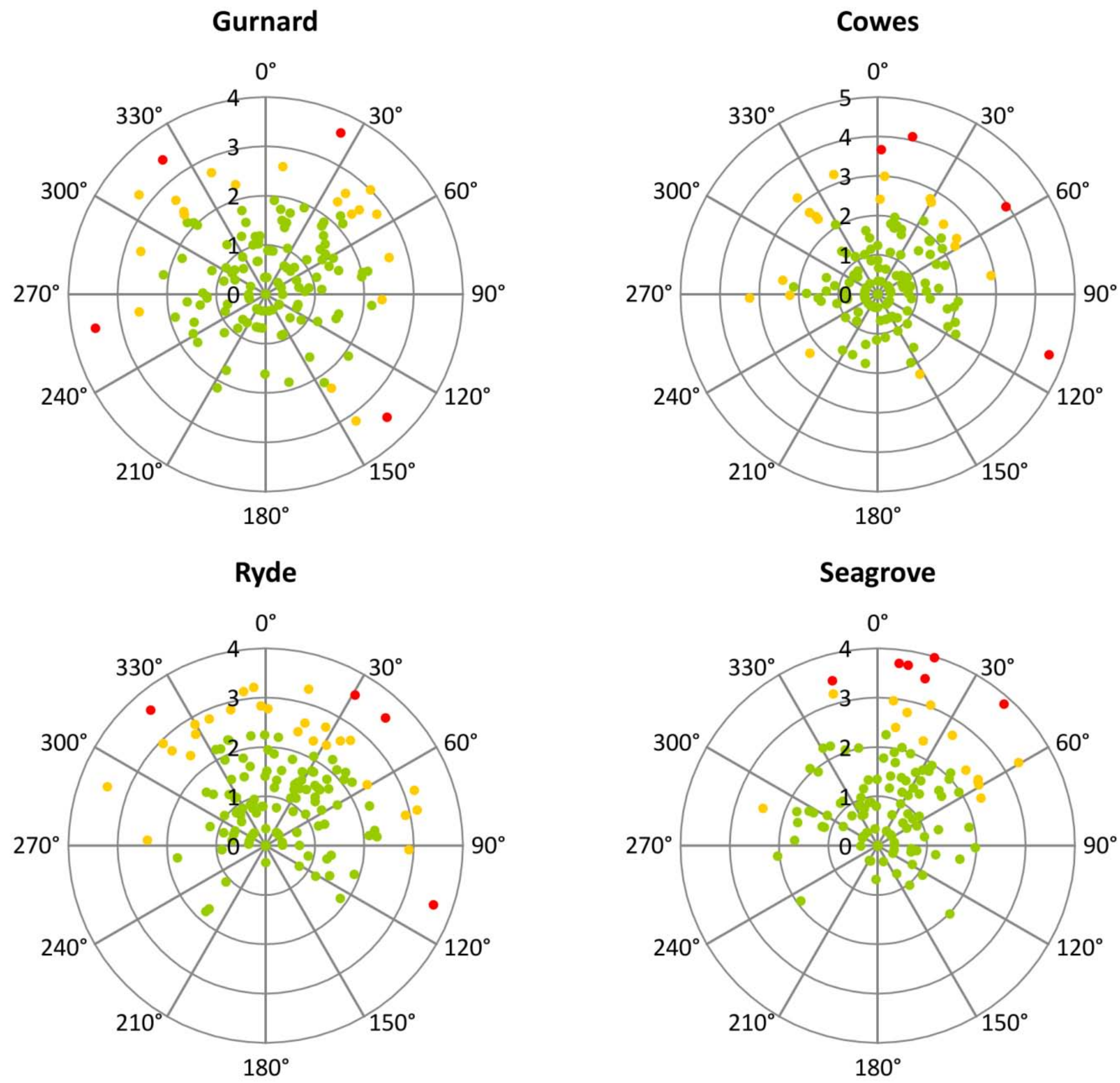


Figure X.3b: Polar plots of log$_{10}$ faecal coliforms against tidal state on the high/low tidal cycle for bathing waters monitoring points with significant correlations
Data from the Environment Agency

At all of the bathing water sites except Southsea, some tendency for higher levels of faecal coliforms around high tide was apparent. At Southsea, faecal coliform levels were highest around low water and on the early flood tide.

Figure X.4 presents polar plots of faecal coliform results against the lunar spring/neap cycle, where a statistically significant correlation was found. Full/new moons occur at 0º, and half moons occur at 180º. The largest (spring) tides occur about 2 days after the full/new moon, or at about 45º, then decrease to the smallest (neap tides) at about 225º, then increase back to spring tides. Results of 100 faecal coliforms/100ml or less are plotted in green, those from 101 to 1000 are plotted in yellow, and those exceeding 1000 are plotted in red.

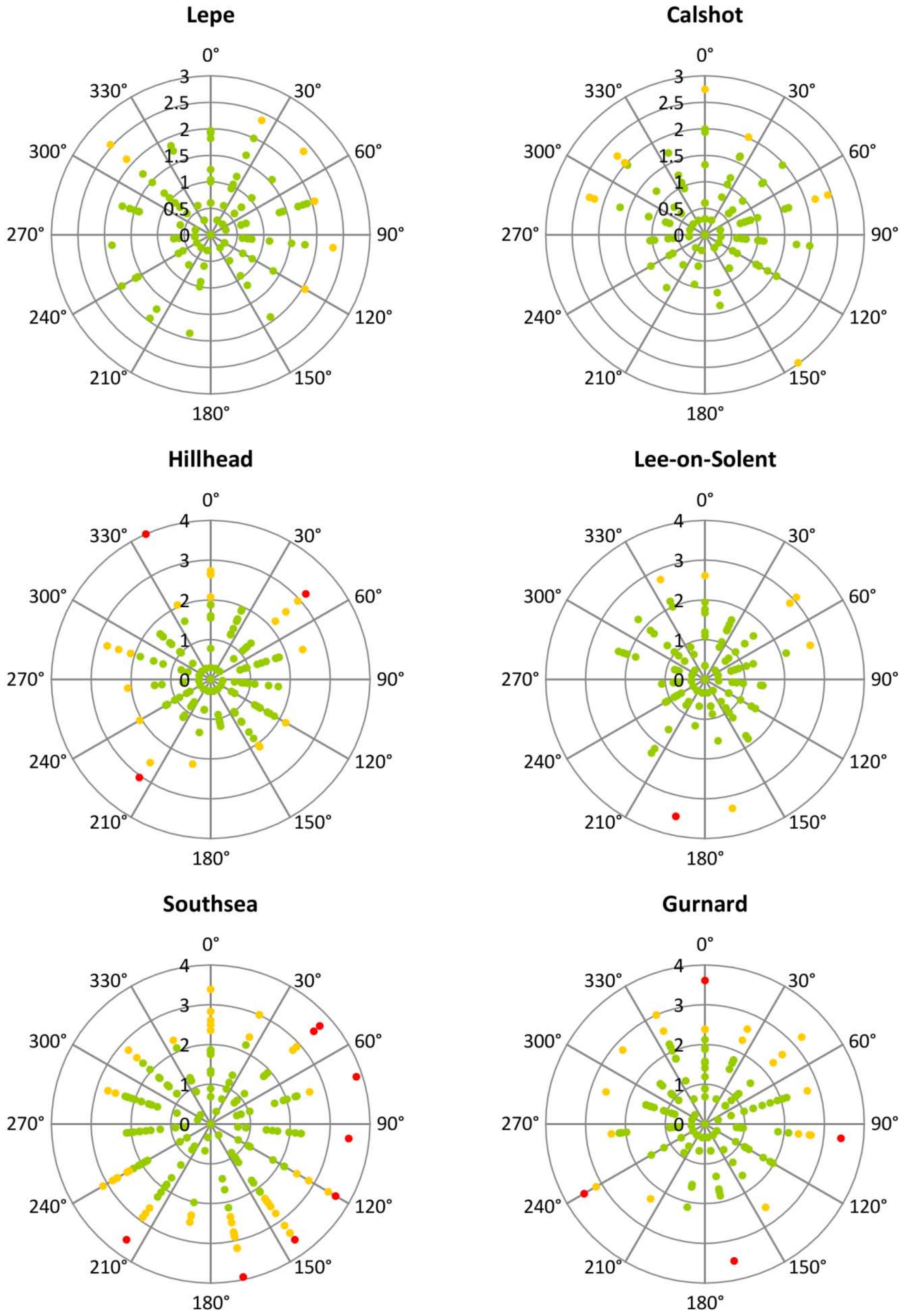


Figure X.4a: Polar plots of log_{10} faecal coliforms against tidal state on the spring/neap tidal cycle for bathing waters monitoring points with significant correlations
Data from the Environment Agency

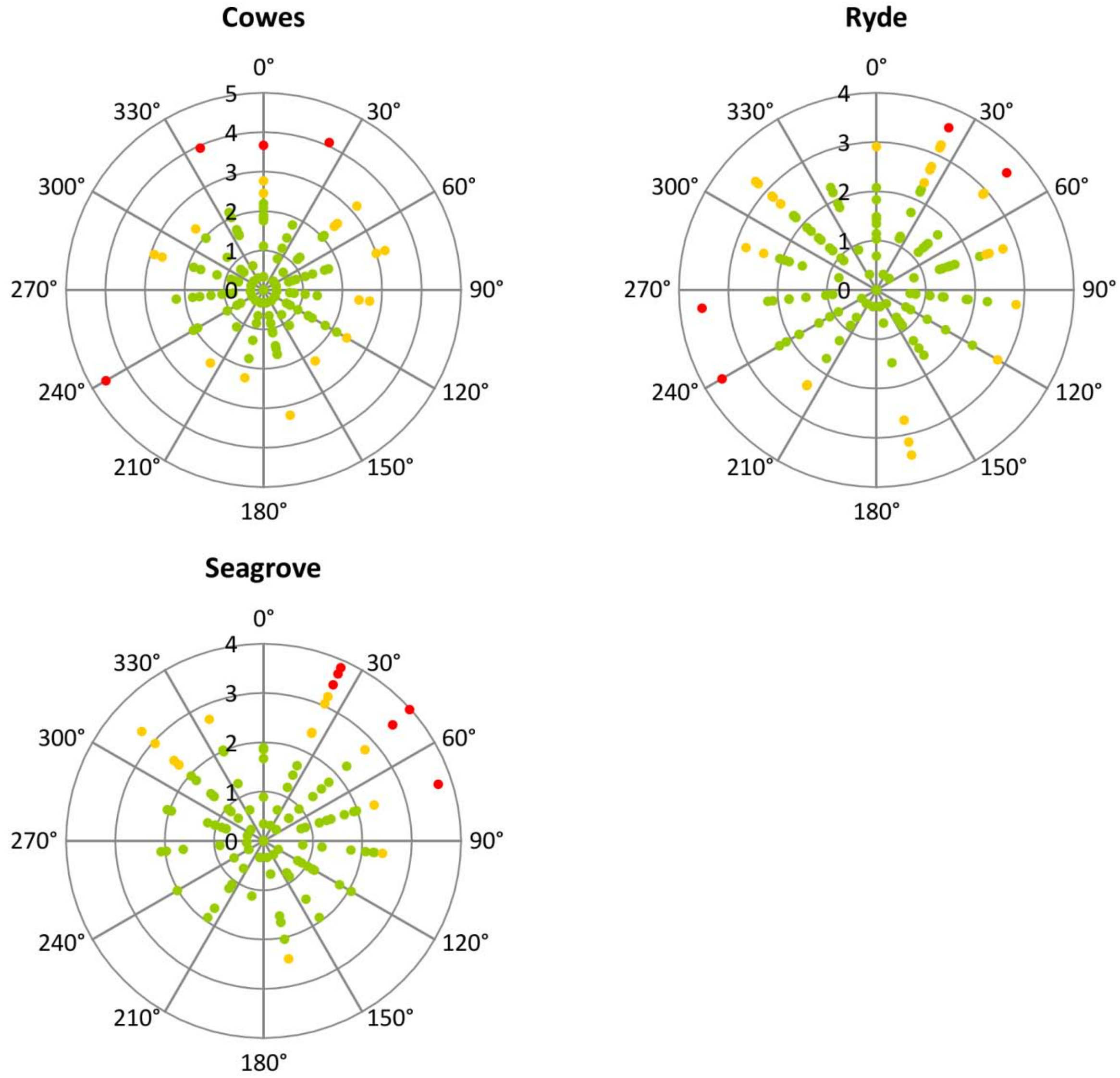


Figure X.4b: Polar plots of $\log_{10}$ faecal coliforms against tidal state on the spring/neap tidal cycle for bathing waters monitoring points with significant correlations
Data from the Environment Agency

Lepe, Calshot, Lee-on-Solent and Seagrove appear to have higher faecal coliform results around spring tides. Southsea had higher results whilst tide size decreased from spring to neap tide. No obvious patterns were apparent at the other sites.

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

Table X.4: Spearmans Rank correlation coefficients for faecal coliforms results against recent rainfall

		Lepe	**Calshot**	**Hillhead**	**Lee-on-Solent**	**Stokes Bay**	**Southsea**	**Gurnard**	**Cowes**	**Ryde**	**Seagrove**
	No.	180	180	180	179	180	180	180	180	181	181
24 hour periods prior to sampling	1 day	0.249	0.231	0.378	0.228	0.185	0.085	0.358	0.231	0.164	0.302
	2 days	0.083	-0.010	0.260	0.308	0.188	0.095	0.448	0.376	0.211	0.221
	3 days	0.202	0.147	0.264	0.249	0.185	-0.010	0.197	0.174	0.219	0.242
	4 days	0.155	0.113	0.095	0.179	0.026	0.038	0.209	0.209	0.092	0.189
	5 days	0.049	0.151	0.122	0.079	-0.058	0.035	0.099	0.162	0.000	0.102
	6 days	0.102	0.127	0.097	0.051	0.038	0.008	0.088	0.279	0.051	0.066
	7 days	0.070	0.145	0.098	0.082	0.055	-0.027	0.175	0.281	0.153	0.011
Total prior to sampling over	2 days	0.210	0.137	0.367	0.281	0.173	0.080	0.452	0.342	0.243	0.265
	3 days	0.231	0.168	0.354	0.288	0.181	0.046	0.404	0.318	0.244	0.304
	4 days	0.265	0.186	0.354	0.312	0.155	0.048	0.355	0.261	0.235	0.305
	5 days	0.222	0.182	0.341	0.279	0.101	0.071	0.363	0.297	0.228	0.339
	6 days	0.243	0.171	0.339	0.238	0.092	0.071	0.353	0.340	0.214	0.313
	7 days	0.245	0.177	0.324	0.214	0.106	0.053	0.349	0.377	0.226	0.276

Data from the Environment Agency

All sites except for Southsea were affected to some degree by rainfall. Most affected sites responded within the first day after a rainfall event, but were no longer affected after 3 to 5 days. Cowes on the other hand continued to be affected by rainfall for at least a week after rain.

SHELLFISH WATERS

Figure X.5 shows the location of the Solent shellfish water monitoring points, designated under Directive 2006/113/EC (European Communities, 2006). Table X.5 and Figure X.6 present summary statistics for bacteriological monitoring results from these monitoring points. Only water sampling results are presented as flesh results from the shellfish hygiene monitoring programme (Appendix XII) are used to assess compliance with bacteriological standards in shellfish flesh.

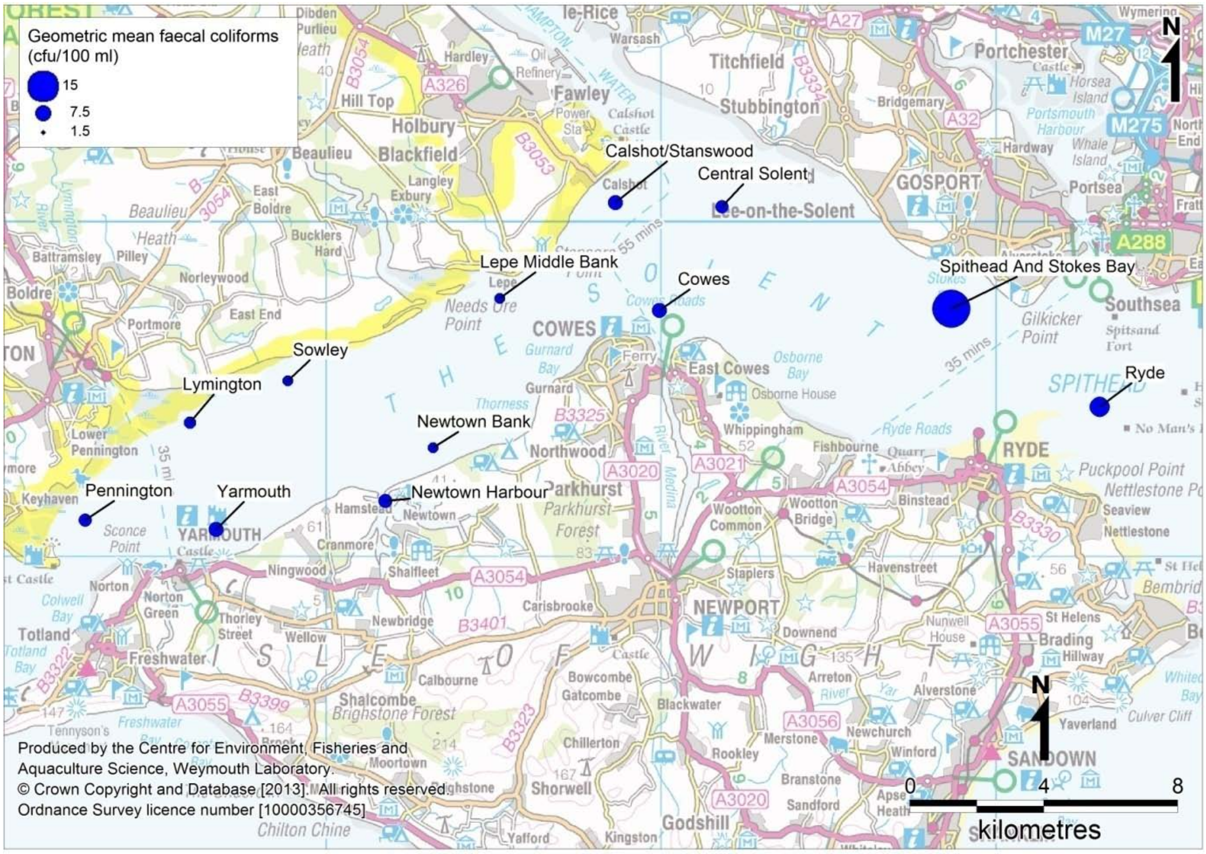


Figure X.5: Thematic map of the Solent showing the locations of shellfish water monitoring points and their geographical mean faecal coliforms/100 ml.

Table X.5: Summary statistics for shellfish waters faecal coliforms results (cfu/100ml).

Site	No.	Geometric mean	Minimum	Maximum	% exceeding 100 cfu/100ml	% exceeding 1000 cfu/100ml
Pennington	51	6.1	1	1455	7.8	2.0
Lymington	51	5.7	1	140	5.9	0.0
Sowley	43	4.1	1	131	2.3	0.0
Lepe Middle Bank	51	3.6	1	112	2.0	0.0
Calshot/Stanswood	51	7.1	2	182	2.0	0.0
Yarmouth	51	7.1	2	80	0.0	0.0
Newtown Harbour	43	6.8	1	370	9.3	0.0
Newtown Bank	51	5.0	1	163	2.0	0.0
Cowes	67	7.2	1	164	7.5	0.0
Central Solent	67	6.1	1	1036	6.0	1.5
Spithead And Stokes Bay	47	18.4	2	2040	14.9	4.3
Ryde	51	9.7	1	310	7.8	0.0

Data from the Environment Agency

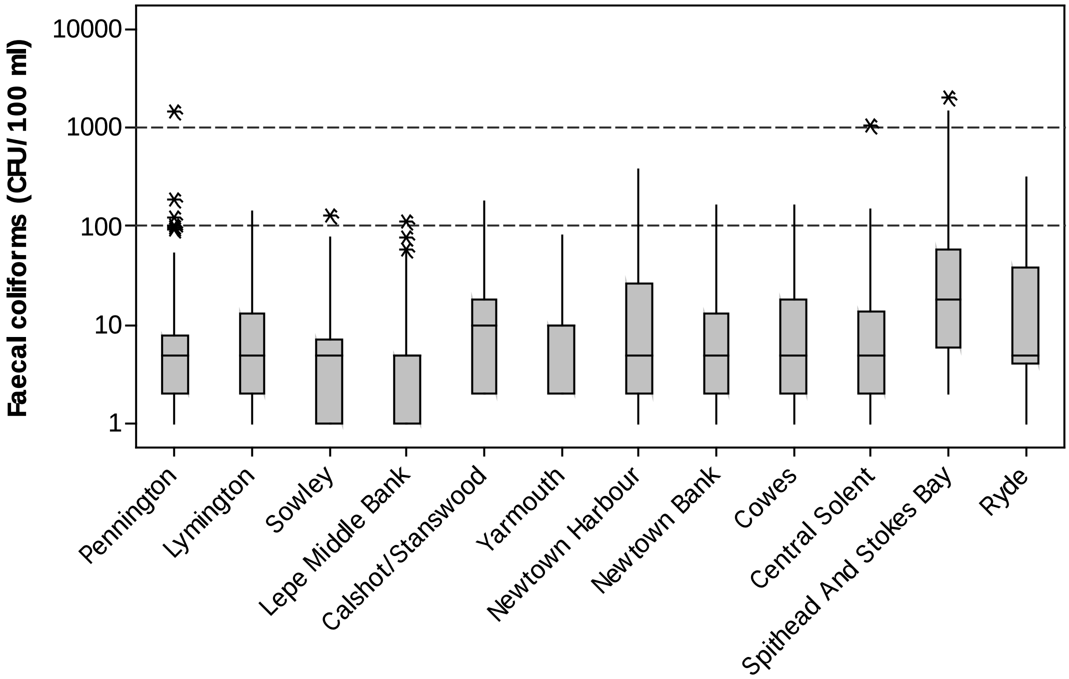


Figure X.6: Boxplot of faecal coliform numbers in Solent shellfish waters

Comparisons of faecal coliform levels (one-way ANOVA) showed that there was a significant difference in contamination across sites (p <0.001). Post ANOVA tests (Tukey) showed that the site “Spithead and Stokes Bay” had significantly greater levels of faecal coliforms than All other sites except Calshot/Stanswood, Yarmouth, Newtown Harbour and Ryde. Additonally Ryde had significantly higher level of faecal coliforms than Lepe Middle Bank.

Pearson’s correlations were used to determine whether salinity affected the level of faecal coliforms present in the shellfish waters at individual sites (Table X.6). Seven of the sites tested had significant negative correlations with salinity suggesting that lower salinity resulted in higher faecal coliform levels.

Table X.6: Pearson's correlations between faecal coliform results (cfu/100 ml) at the Solent shellfish water monitoring points and recorded salinity (ppt). Yellow shaded results indicate a significant correlation (p <0.05).

Site	r	p
Pennington	-0.423	0.035
Lymington	0.044	0.845
Sowley	-0.058	0.819
Lepe Middle Bank	-0.300	0.145
Calshot/Stanswood	-0.396	0.005
Yarmouth	-0.301	0.038
Newtown Harbour	-0.641	0.004
Newtown Bank	-0.157	0.464
Cowes	-0.420	0.007
Central Solent	-0.501	0.001
Spithead And Stokes Bay	-0.127	0.410
Ryde	-0.434	0.039

To investigate the effects of rainfall on levels of contamination at the shellfish waters sites Spearman's rank correlations were carried out between rainfall recorded at the Southgate weather station over various periods running up to sample collection and faecal coliforms results. These are presented in Table X.7 and statistically significant correlations ($p<0.05$) are highlighted in yellow.

Most sites showed some influence of rainfall although this was not particularly strong or consistent. Newtown Harbour and Spithead & Stokes Bay showed no significant correlations with recent rainfall.

Table X.7 Spearman's Rank correlation coefficients for faecal coliforms results against recent rainfall

Site	n	24 hour periods prior to sampling							Total prior to sampling over					
		1 day	2 days	3 days	4 days	5 days	6 days	7 days	2 days	3 days	4 days	5 days	6 days	7 days
Pennington	40	0.226	0.252	0.326	0.164	0.088	-0.014	-0.05	0.365	0.409	0.35	0.279	0.253	0.232
Lymington	40	-0.143	0.209	0.292	0.154	0.037	0.071	-0.17	0.11	0.2	0.21	0.122	0.146	0.031
Sowley	32	-0.048	0.092	0.151	0.339	0.148	-0.113	0.035	0.039	0.127	0.142	0.153	0.097	0.036
Lepe Middle Bank	40	0.233	0.327	0.128	0.309	0.395	0.128	0.271	0.286	0.312	0.29	0.326	0.299	0.242
Calshot/Stanswood	40	0.014	0.354	0.332	0.092	0.141	-0.055	0.189	0.269	0.281	0.263	0.227	0.199	0.149
Yarmouth	40	0.014	0.354	0.332	0.092	0.141	-0.055	0.189	0.269	0.281	0.263	0.227	0.199	0.149
Newtown Harbour	30	-0.012	0.192	0.037	-0.079	0.155	-0.283	0.01	0.178	0.086	-0.003	0.013	-0.088	-0.012
Newtown Bank	40	0.065	0.367	0.32	0.206	0.003	0.03	0.107	0.28	0.326	0.282	0.203	0.205	0.129
Cowes	50	0.108	0.309	0.087	0.087	0.254	0.249	0.144	0.299	0.182	0.17	0.18	0.185	0.17
Central Solent	50	0.094	0.171	0.147	0.187	0.108	0.091	0.241	0.169	0.214	0.22	0.19	0.129	0.192
Spithead And Stokes Bay	36	-0.093	0.211	0.118	-0.042	-0.089	0.049	0.216	0.136	0.146	0.062	0.043	0.023	0.037
Ryde	39	0.051	0.449	0.402	0.266	0.133	0.205	0.105	0.383	0.422	0.408	0.373	0.344	0.308

Data from the Environment Agency

APPENDIX XI
MICROBIOLOGICAL DATA: SHELLFISH FLESH

SUMMARY STATISTICS AND GEOGRAPHICAL VARIATION

There are a total of 35 RMPs in the Solent that have been sampled between 2003 and 2013. Thirty one of these RMPs are for monitoring native oysters, and the other 4 are for cockles and razor clams. Seven of the RMPs were samples on less than 10 occasions and so are not included in statistical analyses. The geometric mean results of shellfish flesh monitoring from all RMPs sampled from 2003 onwards are presented in Figure XI.1 to Figure XI.3. Summary statistics are presented in Table XI.1 and boxplots for sites sampled on 10 or more occasions are shown in Figure XI.4 to Figure XI.6. It should be noted that the three main sewage discharges direct to the Solent were upgraded to provide UV treatment in March 2013. Therefore, the results presented in this report may not be fully representative of the current situation.

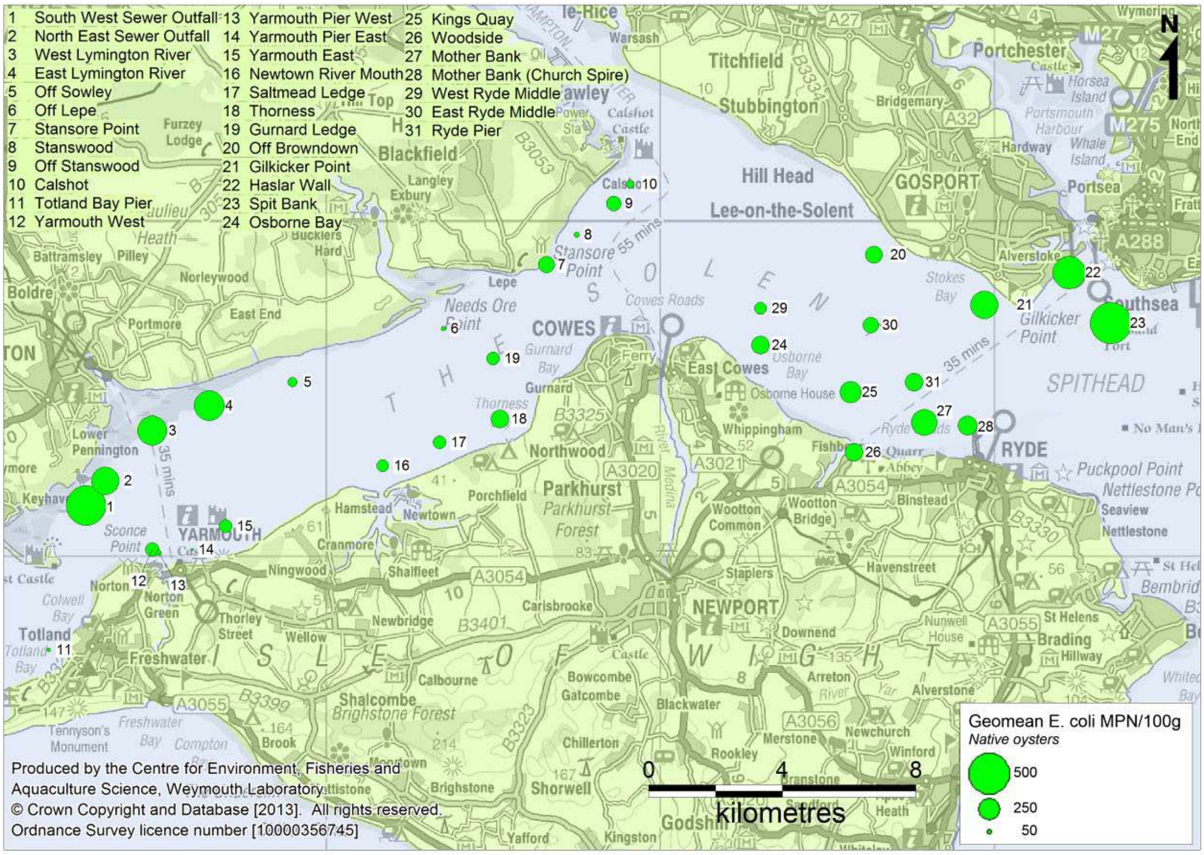


Figure XI.1: Native oyster RMPs active since 2003

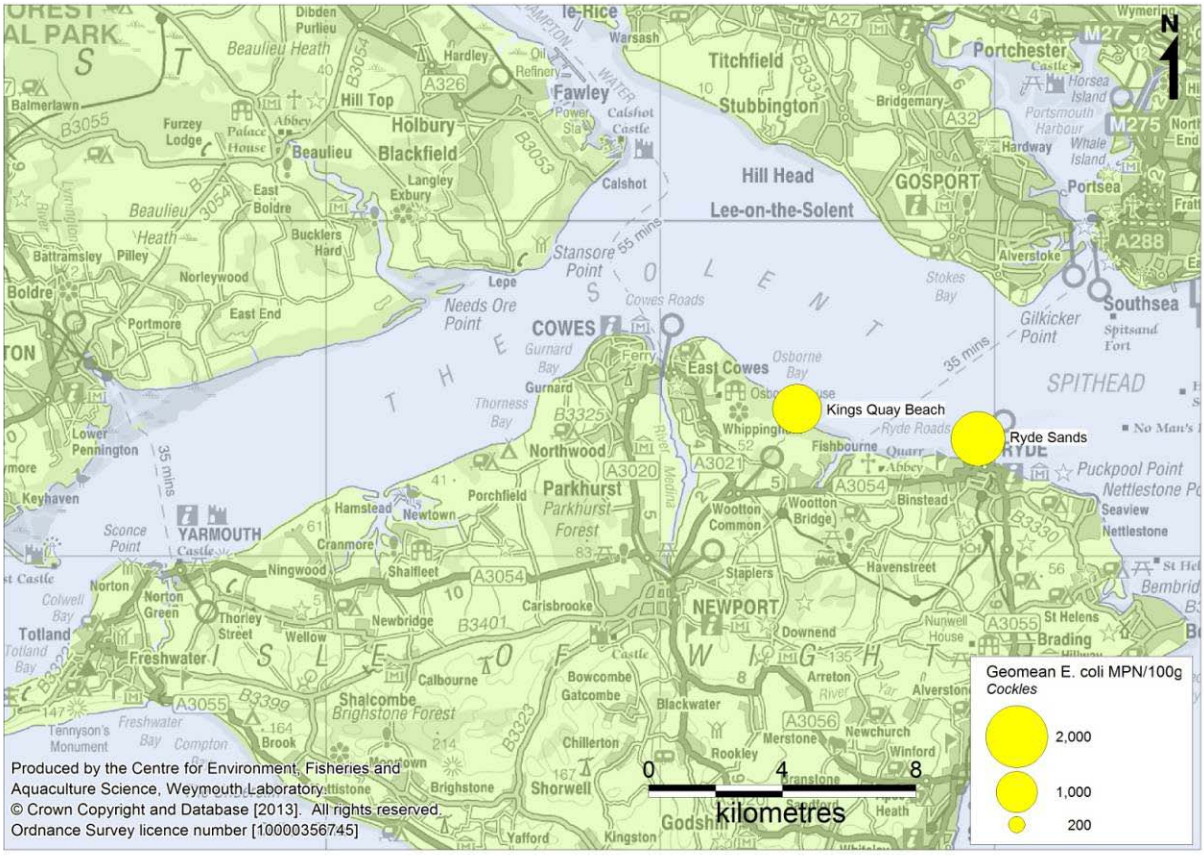


Figure XI.2: Cockle RMPs active since 2003

Figure XI.3: Razor clam RMPs active since 2003

Table XI.1: Summary statistics of E. coli results (MPN/100 g) from native oyster, cockle and razor clam RMPs sampled from 2003 onwards

RMP	Species	No.	Date of first sample	Date of last sample	Geometric mean	Min.	Max.	% over 230	% over 4600
South West Sewer Outfall	Native oyster	110	23/01/2003	05/11/2012	474.9	20	35000	67.3	5.5
North East Sewer Outfall	Native oyster	76	23/01/2003	10/08/2009	334.2	20	17000	59.2	2.6
West Lymington River	Native oyster	79	23/01/2003	10/08/2009	349.8	20	17000	55.7	3.8
East Lymington River	Native oyster	105	23/01/2003	05/11/2012	361.5	<20	24000	60.0	3.8
Off Sowley	Native oyster	2	04/06/2003	06/09/2004	118.3	70	200	0.0	0.0
Off Lepe	Native oyster	112	27/01/2003	05/11/2012	51.7	<20	5400	12.5	0.9
Stansore Point	Native oyster	1	09/12/2003	09/12/2003	200.0	200	200	0.0	0.0
Stanswood	Native oyster	79	27/01/2003	14/09/2009	65.4	<20	35000	17.7	1.3
Off Stanswood	Native oyster	32	12/10/2009	05/11/2012	180.5	<20	24000	43.8	3.1
Calshot	Native oyster	57	27/01/2003	14/07/2009	97.2	<20	1700	28.1	0.0
Totland Bay Pier	Native oyster	63	08/01/2003	07/04/2010	46.1	<20	5400	9.5	1.6
Yarmouth West	Native oyster	87	08/01/2003	14/11/2012	163.0	<20	16000	35.6	1.1
Yarmouth Pier West	Native oyster	6	08/01/2003	29/07/2003	60.4	<20	250	16.7	0.0
Yarmouth Pier East	Native oyster	6	08/01/2003	27/09/2005	31.0	<20	160	0.0	0.0
Yarmouth East	Native oyster	69	08/01/2003	10/03/2010	159.1	<20	9100	36.2	2.9
Newtown River Mouth	Native oyster	91	08/01/2003	14/11/2012	150.5	<20	5400	35.2	1.1
Saltmead Ledge	Native oyster	66	08/01/2003	10/03/2010	153.7	20	9100	37.9	1.5
Thorness	Native oyster	86	08/01/2003	14/11/2012	223.6	<20	16000	50.0	2.3
Gurnard Ledge	Native oyster	1	13/03/2006	13/03/2006	160.0	160	160	0.0	0.0
Off Browndown	Native oyster	113	27/01/2003	05/11/2012	209.5	<20	16000	42.5	4.4
Gilkicker Point	Native oyster	113	27/01/2003	05/11/2012	335.0	20	14000	54.9	2.7
Haslar Wall	Native oyster	39	07/01/2003	10/04/2006	391.0	<20	24000	71.8	2.6
Spit Bank	Native oyster	116	07/01/2003	30/10/2012	500.5	<20	17000	70.7	6.0
Osborne Bay	Native oyster	88	20/01/2003	14/11/2012	218.8	<20	4300	45.5	0.0
Kings Quay	Native oyster	88	20/01/2003	14/11/2012	260.6	20	16000	47.7	2.3
Woodside	Native oyster	1	13/02/2006	13/02/2006	220.0	220	220	0.0	0.0
Mother Bank	Native oyster	8	20/01/2003	15/09/2003	313.0	50	1700	62.5	0.0
Mother Bank (Church Spire)	Native oyster	61	13/10/2003	15/03/2010	227.1	<20	5400	45.9	1.6
West Ryde Middle	Native oyster	84	27/01/2003	02/03/2010	144.3	<20	3500	32.1	0.0
East Ryde Middle	Native oyster	35	27/01/2003	06/02/2006	188.3	<20	3500	37.1	0.0
Ryde Pier	Native oyster	110	27/01/2003	05/11/2012	216.3	20	14000	41.8	2.7
Kings Quay Beach	Cockle	62	12/04/2005	04/10/2012	1331.6	<20	>180000	83.9	21.0
Ryde Sands	Cockle	71	09/07/2004	04/10/2012	1583.6	<20	35000	84.5	35.2
Kings Quay Beach	Razor clam	21	17/07/2003	22/09/2009	1115.1	<20	91000	81.0	14.3
Ryde Sands	Razor clam	11	09/05/2005	31/10/2007	561.1	20	7500	63.6	9.1

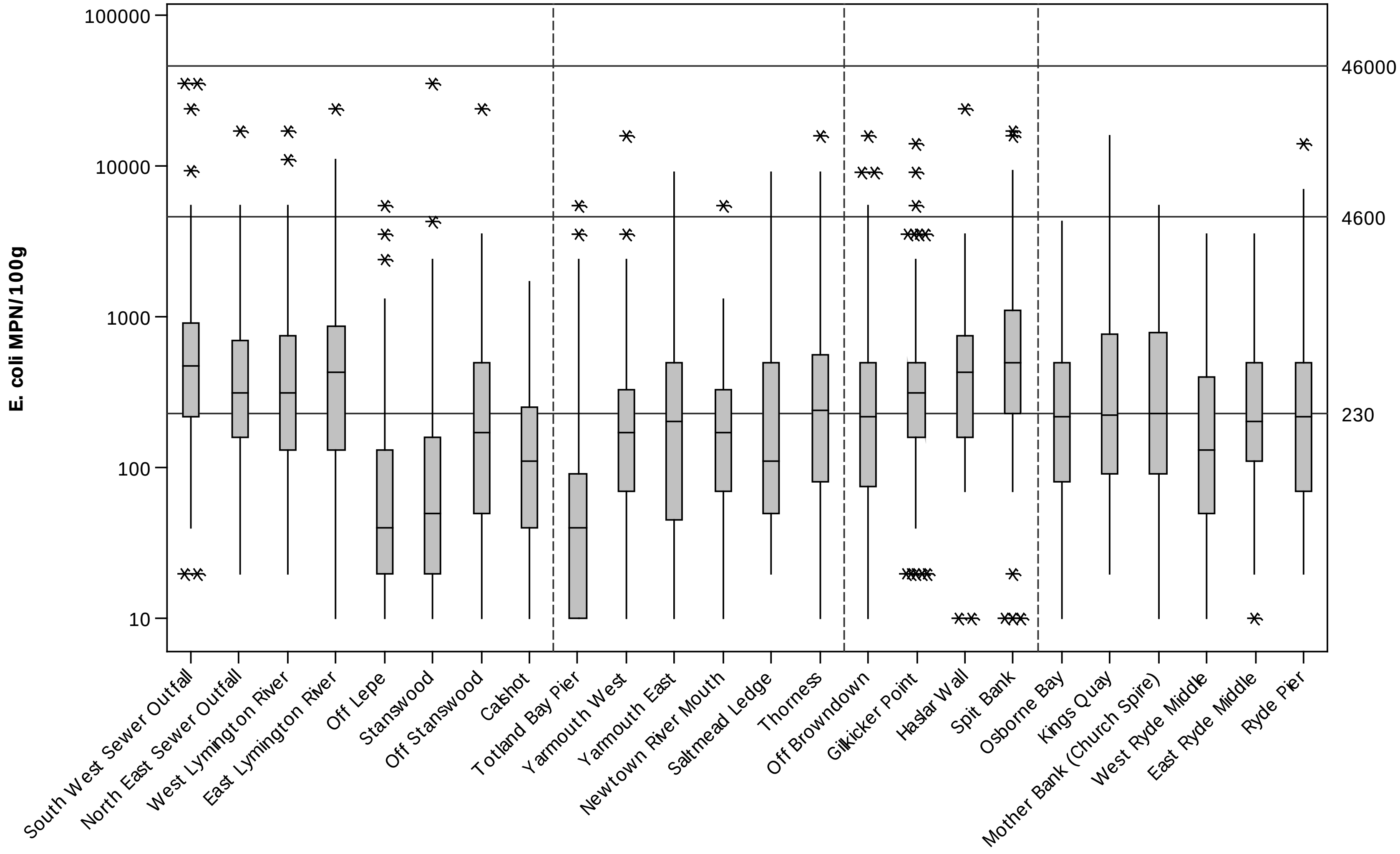


Figure XI.4: Boxplots of E. coli results from native oyster RMPs sampled on 10 or more occasions from 2003 onwards.

E. coli levels in native oysters exceeded 4600 MPN/100 g at least once at most of the RMPs, but never exceeded 46000 MPN/100 g at any RMP. Compliance with class B requirements was apparent at all. Across the north west Solent, results were higher on average at the western end off Lymington and Keyhaven. Results were markedly lower from Lepe to Calshot, with a secondary peak off Stanswood. Within the south west Solent, results were lowest at Totland Bay Pier and were broadly similar from Yarmouth through to Thorness. Across the north east Solent, the average result steadily increased across the four nearshore RMPs from Browndown through to Spit Bank. Results were very similar across the three main RMPs in the south east Solent (Osbourne Bay, Kings Quay and Mother Bank Church Spire). Results in the central eastern Solent (East and West Ryde Middle and Ryde Pier) were slightly lower on average compared to other RMPs in the eastern Solent which were located closer to the shore. Comparisons of the sites (1-way ANOVA) showed that there were significant differences in the *E. coli* levels (p<0.001) across these RMPs. Table XI.2 shows a matrix of the results of post ANOVA (Tukey) tests which compared *E. coli* levels at each site on a pair-wise basis.

Table XI.2: Matrix to show results of post ANOVA Tukey tests of significance of differences (p<0.05 is significant) in E. coli levels between native oyster RMPs. Grey boxes indicate that there was no significant differences; green boxes indicate that the site on the top side of the matrix had greater average E. coli results than the site on the left side of the matrix; red boxes indicate that the site on the top side of the matrix has lower average E. coli results than the site on the left side of the matrix. *Site 1 is "South West Sewer Outfall".

		1*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2	North East Sewer Outfall																							
3	West Lymington River																							
4	East Lymington River																							
5	Off Lepe																							
6	Stanswood																							
7	Off Stanswood																							
8	Calshot																							
9	Totland Bay Pier																							
10	Yarmouth West																							
11	Yarmouth East																							
12	Newtown River Mouth																							
13	Saltmead Ledge																							
14	Thorness																							
15	Off Browndown																							
16	Gilkicker Point																							
17	Haslar Wall																							
18	Spit Bank																							
19	Osborne Bay																							
20	Kings Quay																							
21	Mother Bank (Church Spire)																							
22	West Ryde Middle																							
23	East Ryde Middle																							
24	Ryde Pier																							

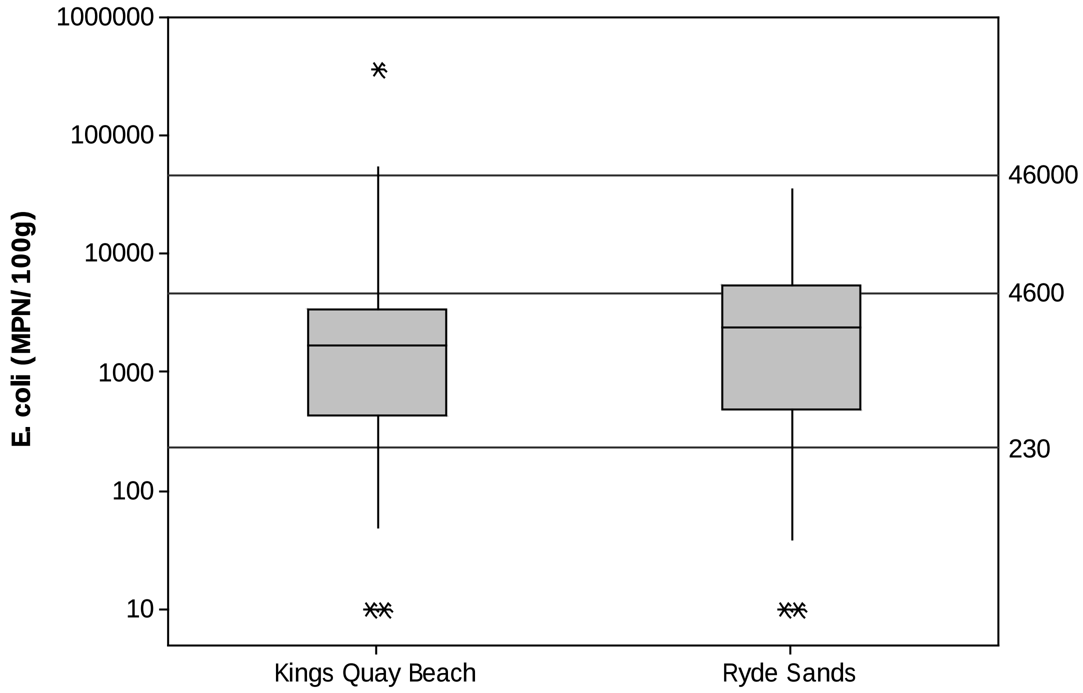


Figure XI.5: Boxplots of E. coli results from cockle RMPs sampled on 10 or more occasions from 2003 onwards.

Both of the cockle RMPs had *E. coli* results exceeding 4,600 MPN/100 g more that 10% of the time suggesting class B compliance is unlikely. However, *E. coli* levels only exceeded 46,000 MPN/100 g at Kings Quay Beach. Comparisons showed that there was no significant difference between the sites (T-test, p=0.588).

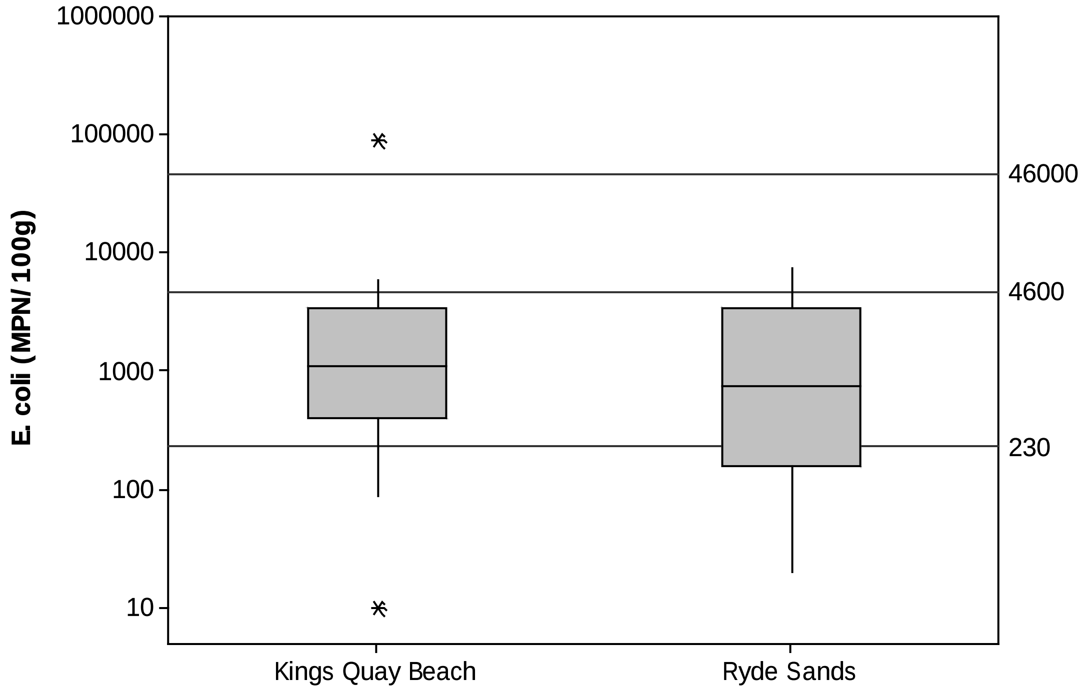


Figure 6: Boxplots of E. coli results from razor clam RMPs sampled on 10 or more occasions from 2003 onwards.

Both of the razor clam RMPs had *E. coli* results exceeding 4,600 MPN/100 g, but *E. coli* levels only exceeded 46,000 MPN/100 g at Kings Quay Beach. Comparisons showed that there was no significant difference between the sites (T-test, p=0.333).

More robust comparisons of RMPs were carried out on a pair-wise basis by running correlations (Pearson's) between sites that shared sampling dates, and therefore environmental conditions, on at least 20 occasions. Non-significant results suggest that some sites are influenced by a different range of sources which react in a different manner to environmental conditions. It was not possible to undertake meaningful paired comparisons between razor clam RMPs as fewer than 20 same day samples were taken for each of these pairings.

These comparisons indicate that in most cases where comparisons were possible correlations were found, even between sites some distance away suggesting the entire Solent is under broadly similar influences. Along the north west coast of the Isle of Wight all possible site comparisons were strongly correlated. The same applied to site comparisons made along the north east coast of the Isle of Wight. Not all sites showed correlations along the western mainland coast. Only one comparison was possible along the eastern mainland coast (Browndown and Gillkicker) where there was a correlation.

Table XI.3: Correlations between RMPs that shared sampling dates on at least 20 occasions. Comparison that were not possible are shaded in grey; yellow boxes indicate a significant correlation (and correlation coefficients are displayed in these boxes); green boxes indicate a non-significant correlation. *Site 1 is "South West Sewer Outfall"

		1*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2	North East Sewer Outfall	0.646																						
3	West Lymington River	0.367	0.385																					
4	East Lymington River	0.305	0.273																					
5	Off Lepe	0.331			0.522																			
6	Stanswood					0.519																		
7	Off Stanswood				0.689	0.640																		
8	Calshot						0.484																	
9	Totland Bay Pier																							
10	Yarmouth West																							
11	Yarmouth East										0.629													
12	Newtown River Mouth									0.608	0.598	0.572												
13	Saltmead Ledge									0.500	0.657	0.643												
14	Thorness									0.504	0.682	0.612												
15	Off Browndown					0.394	0.321	0.464																
16	Gilkicker Point					0.343	0.348									0.574								
17	Haslar Wall																							
18	Spit Bank																							
19	Osborne Bay																							
20	Kings Quay																			0.720				
21	Mother Bank (Church Spire)																			0.457				
22	West Ryde Middle					0.404	0.432		0.502							0.572	0.518							
23	East Ryde Middle					0.522											0.368						0.661	
24	Ryde Pier					0.474	0.360		0.457							0.534	0.533		0.417				0.685	0.340

OVERALL TEMPORAL PATTERN IN RESULTS

The overall variation in *E. coli* levels found in bivalves since 2003 is shown in Figure XI.7 to Figure XI.11. Not enough data exist for razor clam beds to show a useful pattern and so results for these were not included here. Only samples with data for more than two years were included.

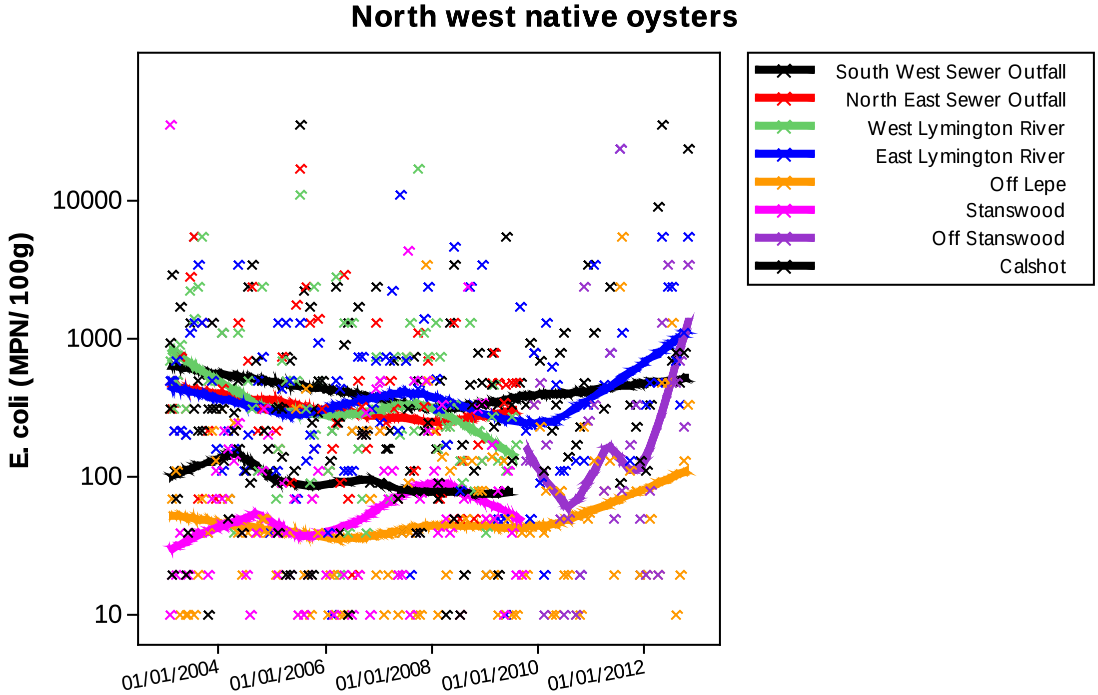


Figure XI.7: Scatterplot of E. coli results for native oysters in the north west Solent overlaid with loess lines.

Most of the native oyster RMPs in the north-west Solent had fairly consistent *E. coli* levels. West Lymington River appeared to a decrease from 2003 to 2010 before sampling stopped here. There appears to have been an increasing trend since 2010 to some extent in all four RMPs sampled during this period.

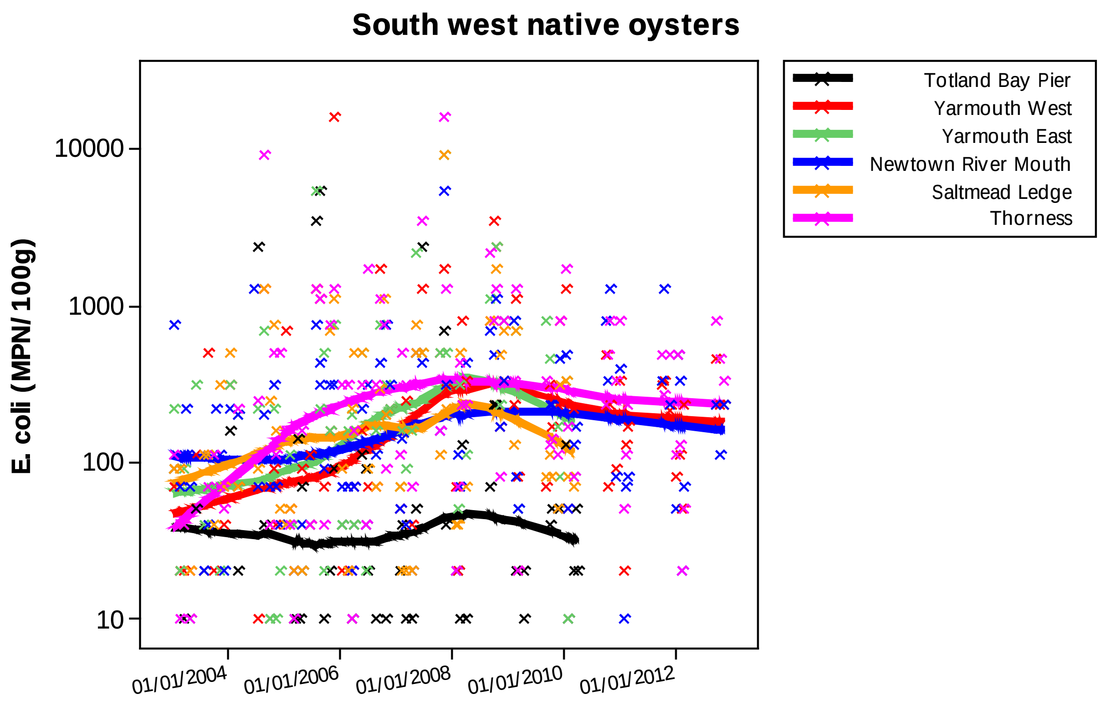


Figure XI.8: Scatterplot of E. coli results for native oysters in the south west Solent overlaid with loess lines.

In the south-west Solent, most native oyster RMPs have had a slight increase in *E. coli* levels from 2003 to 2008, but appear to have remained fairly constant since.

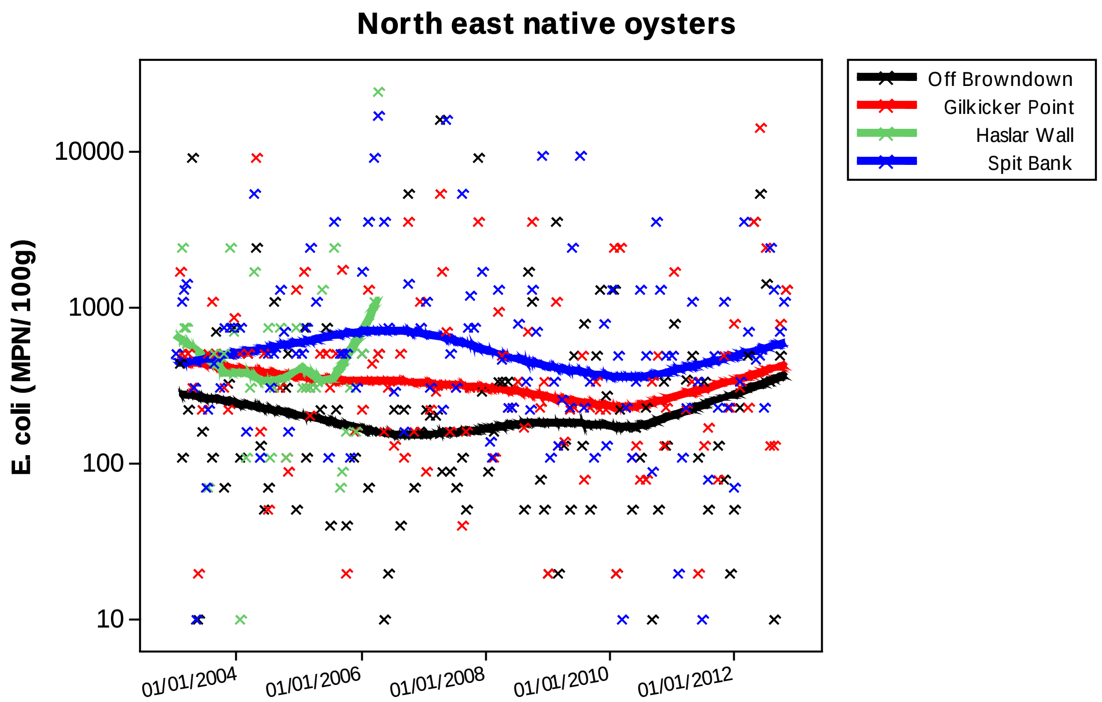


Figure XI.9: Scatterplot of E. coli results native oysters in the north east Solent overlaid with loess lines.

All of the native oyster RMPs in the north-east Solent have remained reasonably consistent from 2003 onwards.

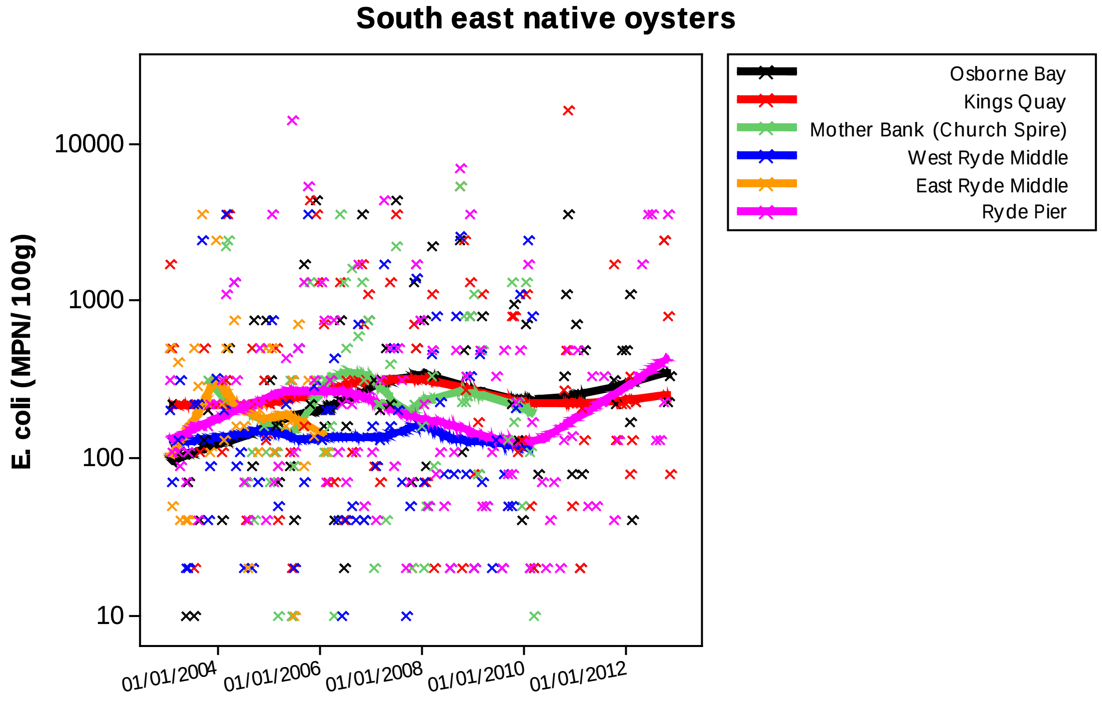


Figure XI.10: Scatterplot of E. coli results for native oysters in the south east Solent overlaid with loess lines.

All of the native oyster RMPs in the south-east Solent have remained fairly consistent from 2003 onwards.

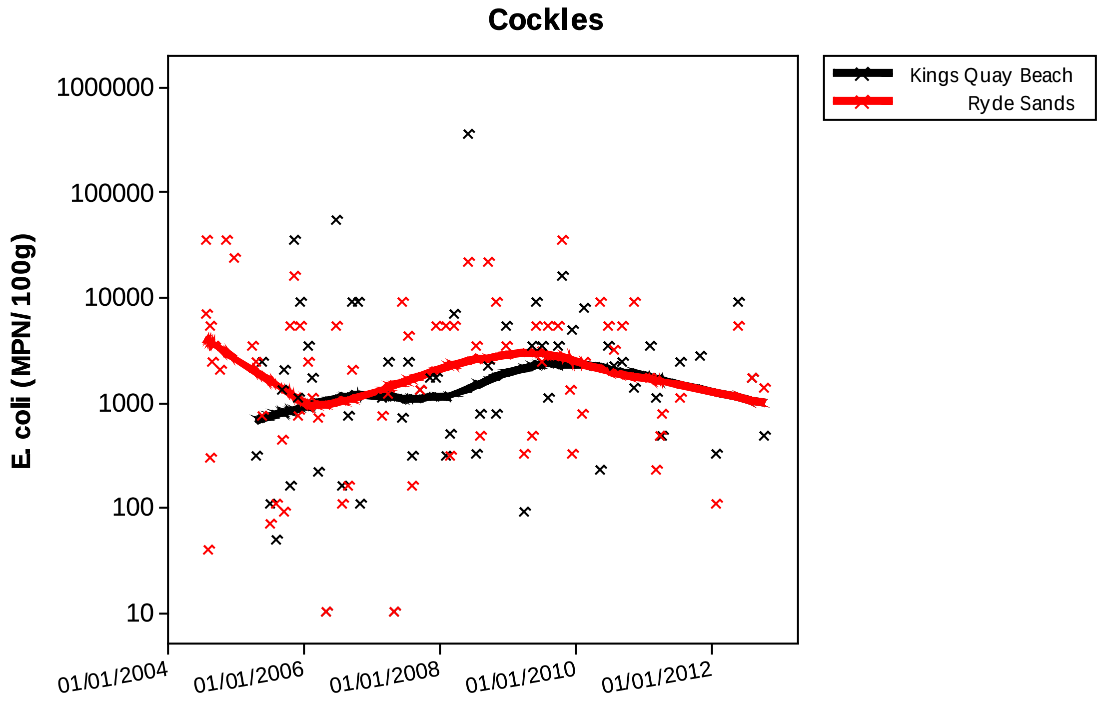


Figure XI.11: Scatterplot of E. coli results for cockles overlaid with loess lines.

Both of the cockle RMPs in the Solent have remained consistent from 2003 onwards.

SEASONAL PATTERNS OF RESULTS

A significant difference was found between seasons for the combined results from all native oyster RMPs (one-way ANOVA, p<0.001). Post ANOVA testing (Tukeys comparison) revealed that *E. coli* levels were significantly higher in the autumn than at any other time of year.

The seasonal patterns of results from 2003 onwards were investigated by RMP for all RMPs where at least 30 samples had been taken. Boxplots of results by season are presented in Figures XI.13 to XI.16. These indicate a relatively clear pattern of higher results in the summer/autumn period in the south west Solent, and to a lesser extent at more inshore RMPs in the south east Solent, with little or no clear patterns elsewhere.

Comparisons of *E. coli* levels by season for individual native oyster RMP showed that in the majority of cases there was no difference between seasons (one-way ANOVA, p=0.076–0.914 for 16 RMPs). At eight RMPs, significant differences were found between seasons and Tukey comparisons were used to determine the root of the differences. At Stanswood (p=0.015) winter and autumn *E. coli* levels were greater than in summer. At Totland Bay Pier (p=0.001) summer *E. coli* levels were greater than in spring. At Yarmouth West (p=0.037) autumn *E. coli* levels were greater than in winter. At Newtown River Mouth (p=0.001) autumn *E. coli* levels were greater than spring and in winter. At Saltmead Ledge (p=0.01) autumn *E. coli* levels were greater than spring and in winter. At Thorness (p=0.013) summer and autum *E. coli* levels were greater than in spring. At Osborne Bay (p=0.001) autumn *E. coli* levels were greater than summer and in winter. At Kings Quay (p=0.028) autumn *E. coli* levels were greater than in summer.

No differences were found between seasons in either of the two cockle RMPs (p=0.489 and 0.106 for Kings Quay Beach and Ryde Sands respectively).

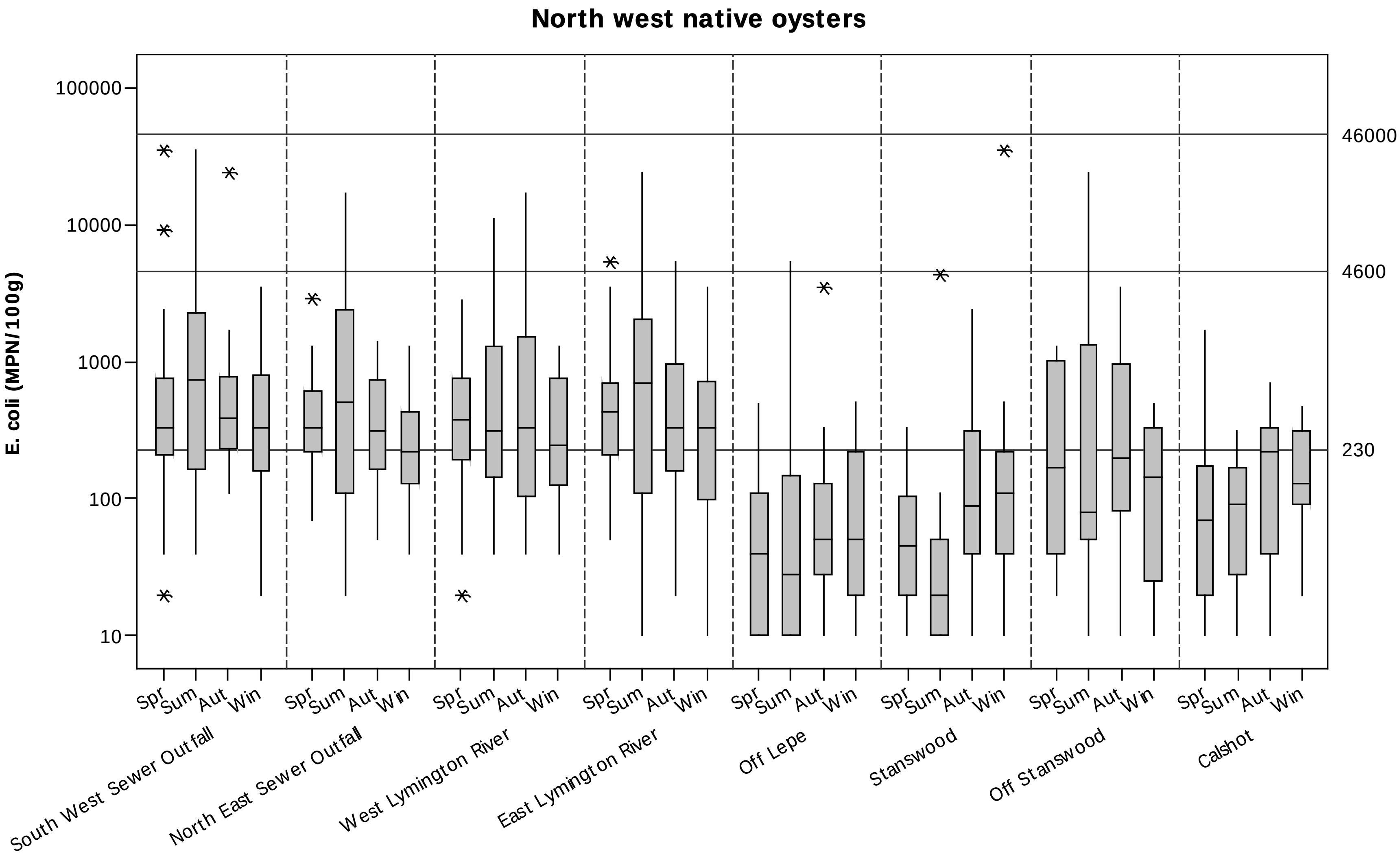


Figure XI.13: Boxplot of E. coli results in native oysters in the north west Solent by RMP and season

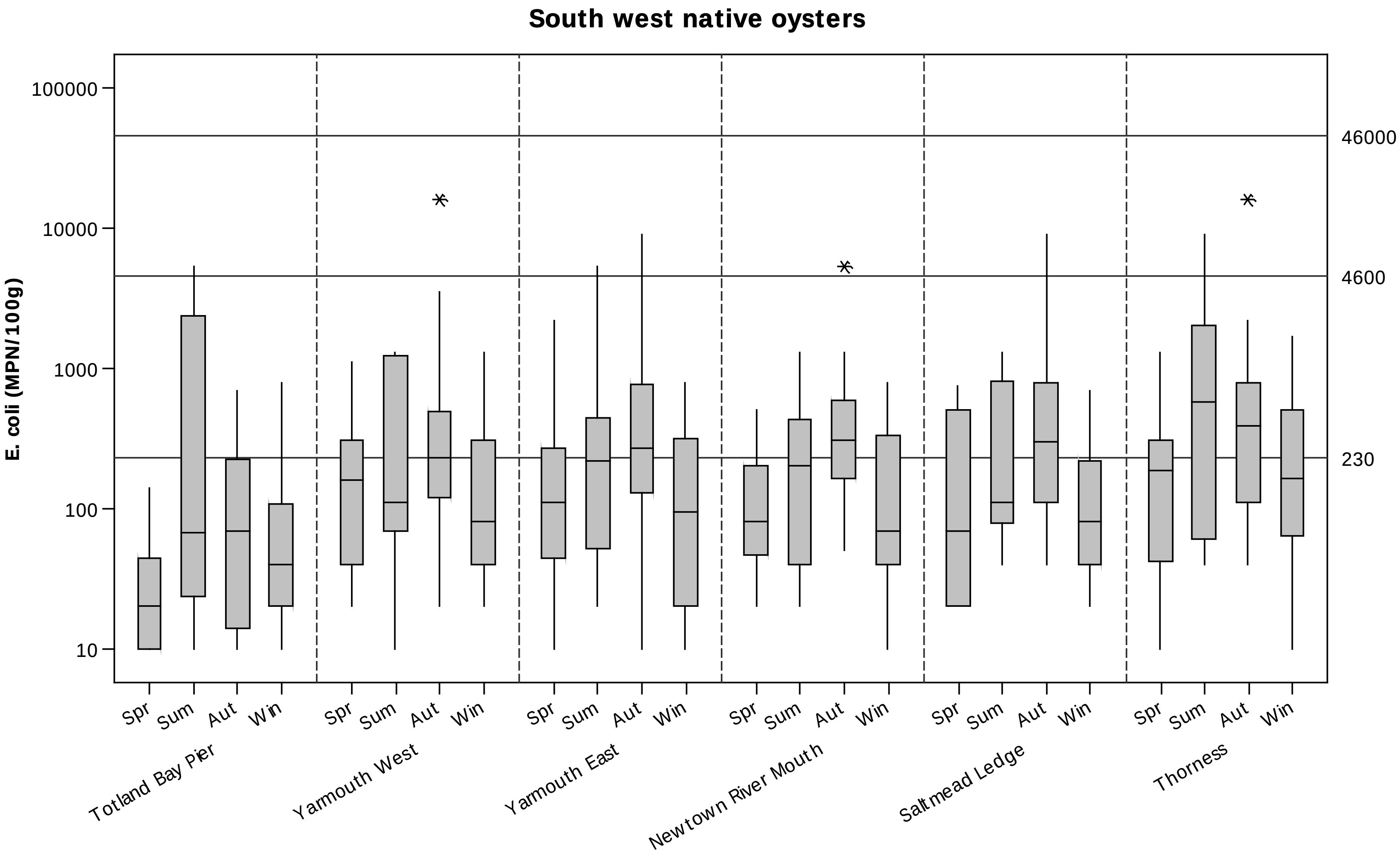


Figure XI.14: Boxplot of E. coli results in native oysters in the south west Solent by RMP and season

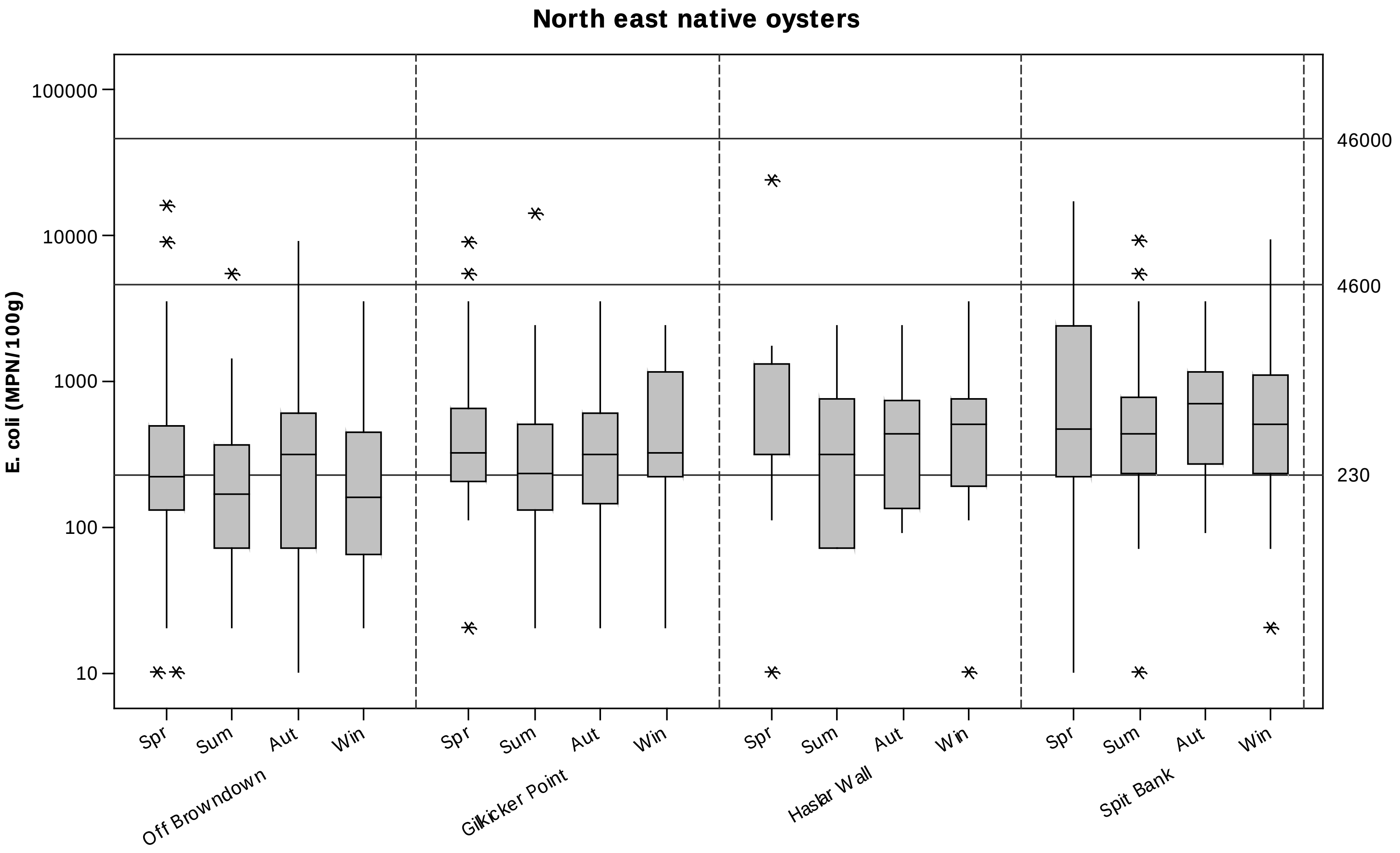


Figure XI.15: Boxplot of E. coli results in native oysters in the north east Solent by RMP and season

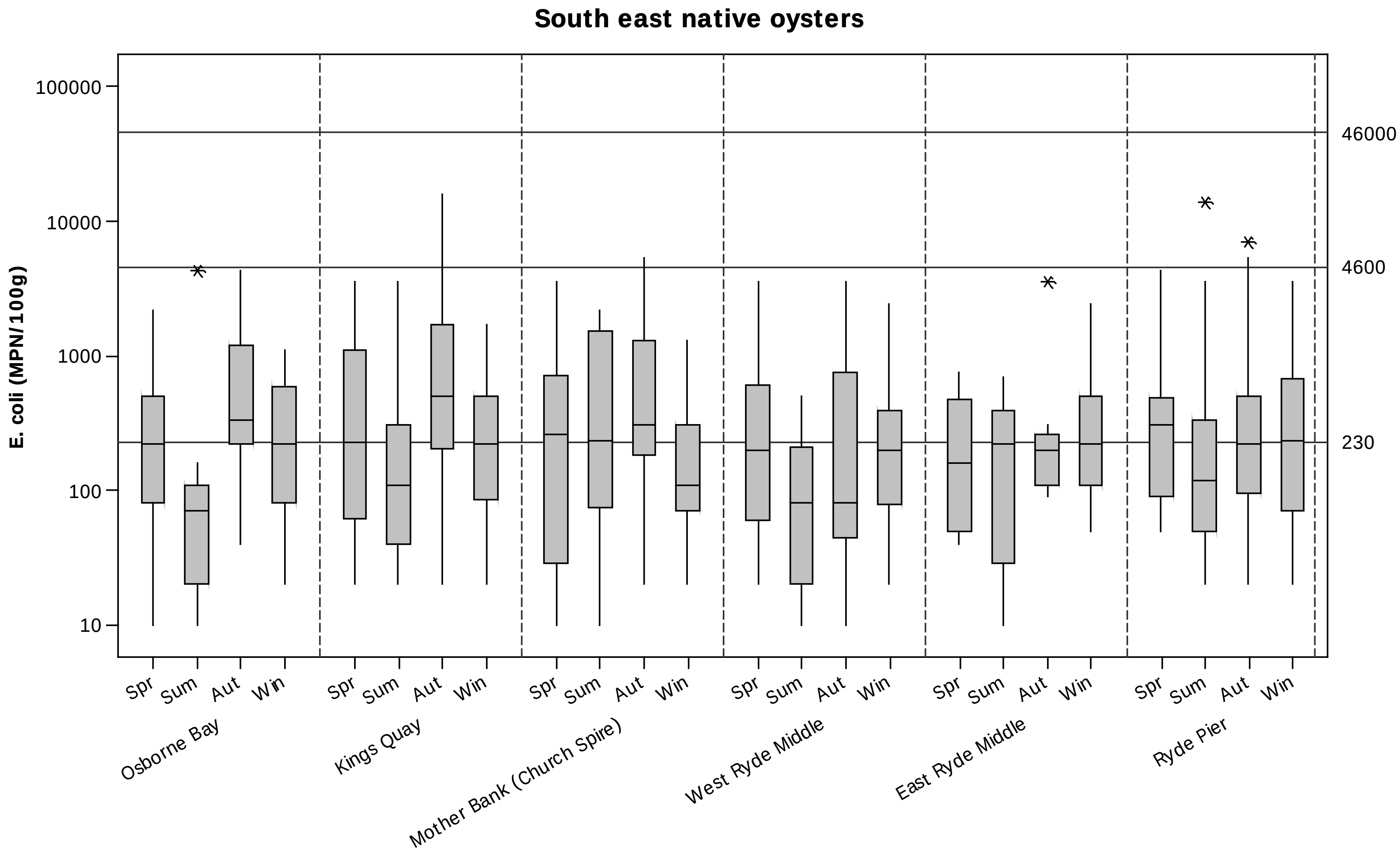


Figure XI.16: Boxplot of E. coli results in native oysters in the south east Solent by RMP and season

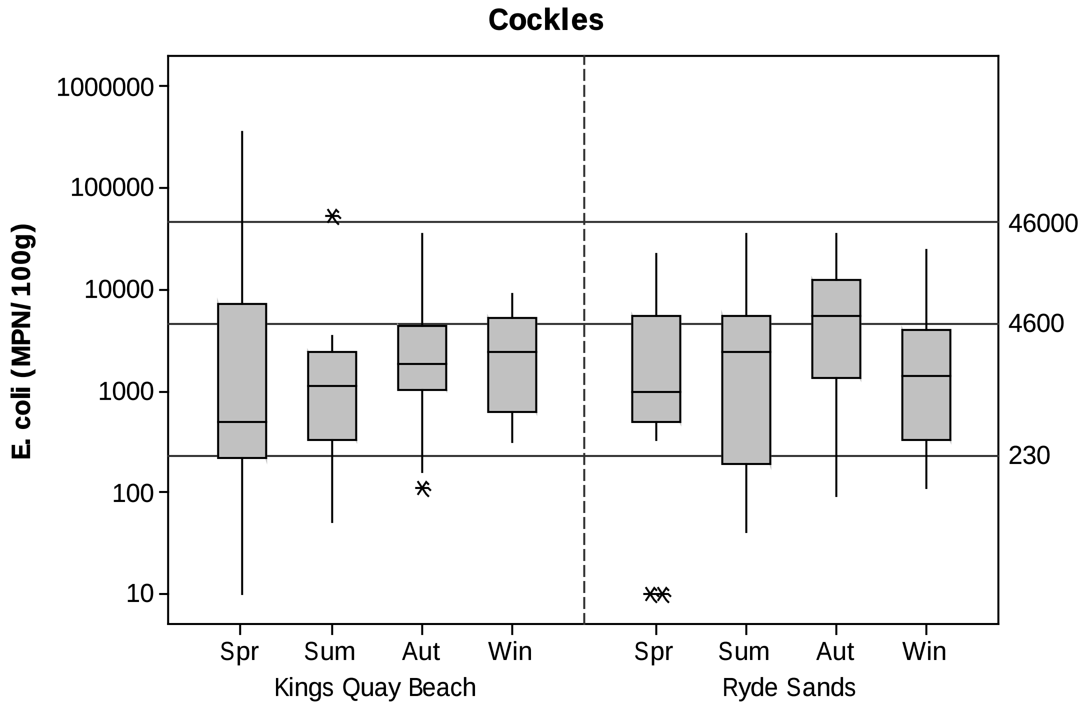


Figure XI.17: Boxplot of cockle E. coli results by RMP and season

INFLUENCE OF TIDE

To investigate the effects of tidal state on *E. coli* results, circular-linear correlations were carried out against the spring/neap tidal cycle for each RMP where at least 30 samples had been taken. Results of these correlations are summarised in Table XI.4, and significant results are highlighted in yellow.

Table XI.4: Circular linear correlation coefficients (r) and associated p values for E. coli results against the high/low and spring/neap tidal cycles

Site	Species	High/low r	High/low p	Spring/neap R	Spring/neap p
South West Sewer Outfall	Native oyster	0.299	<0.001	0.284	<0.001
North East Sewer Outfall	Native oyster	0.276	0.004	0.257	0.008
West Lymington River	Native oyster	0.170	0.112	0.066	0.715
East Lymington River	Native oyster	0.125	0.202	0.131	0.175
Off Lepe	Native oyster	0.129	0.164	0.063	0.645
Stanswood	Native oyster	0.145	0.201	0.171	0.109
Off Stanswood	Native oyster	0.279	0.112	0.338	0.036
Calshot	Native oyster	0.374	<0.001	0.283	0.013
Totland Bay Pier	Native oyster	0.219	0.057	0.171	0.173
Yarmouth West	Native oyster	0.447	<0.001	0.353	<0.001
Yarmouth East	Native oyster	0.153	0.212	0.303	0.002
Newtown River Mouth	Native oyster	0.190	0.041	0.237	0.007
Saltmead Ledge	Native oyster	0.158	0.207	0.211	0.060
Thorness	Native oyster	0.184	0.059	0.201	0.035
Off Browndown	Native oyster	0.246	0.001	0.338	<0.001
Gilkicker Point	Native oyster	0.187	0.021	0.236	0.002
Haslar Wall	Native oyster	0.375	0.006	0.268	0.074
Spit Bank	Native oyster	0.240	0.002	0.280	<0.001
Osborne Bay	Native oyster	0.244	0.006	0.170	0.085
Kings Quay	Native oyster	0.092	0.485	0.126	0.262
Mother Bank (Church Spire)	Native oyster	0.268	0.016	0.253	0.025
West Ryde Middle	Native oyster	0.209	0.029	0.253	0.006
East Ryde Middle	Native oyster	0.094	0.753	0.222	0.206
Ryde Pier	Native oyster	0.083	0.475	0.108	0.285
Kings Quay Beach	Cockle	0.517	<0.001	0.452	<0.001
Ryde Sands	Cockle	0.335	<0.001	0.256	0.012
Kings Quay Beach	Razor clam	0.213	0.442	0.399	0.056
Ryde Sands	Razor clam	0.366	0.340	0.532	0.097

Figures XI.18 and XI.19 present polar plots of $\log_{10}$ *E. coli* results against tidal states on the high/low cycle for the correlations indicating a statistically significant effect. High water at Stansore Point is at 0° and low water is at 180°. Results of 230 *E. coli* MPN/100g or less are plotted in green, those from 231 to 4600 are plotted in yellow, and those exceeding 4600 are plotted in red.

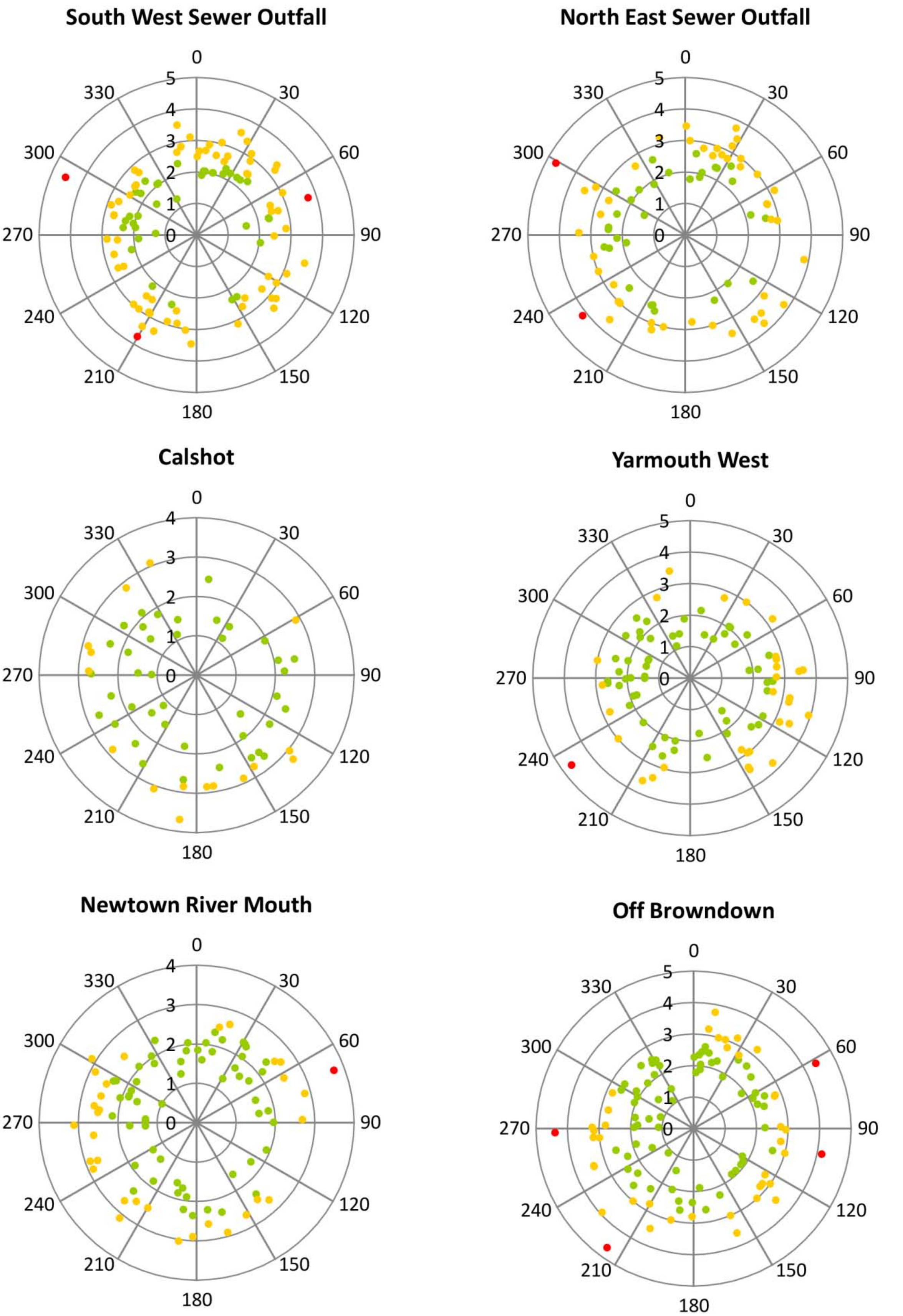


Figure XI.18a: Polar plots of log10 E. coli results (MPN/100g) in against high/low tidal state for native oyster RMPs

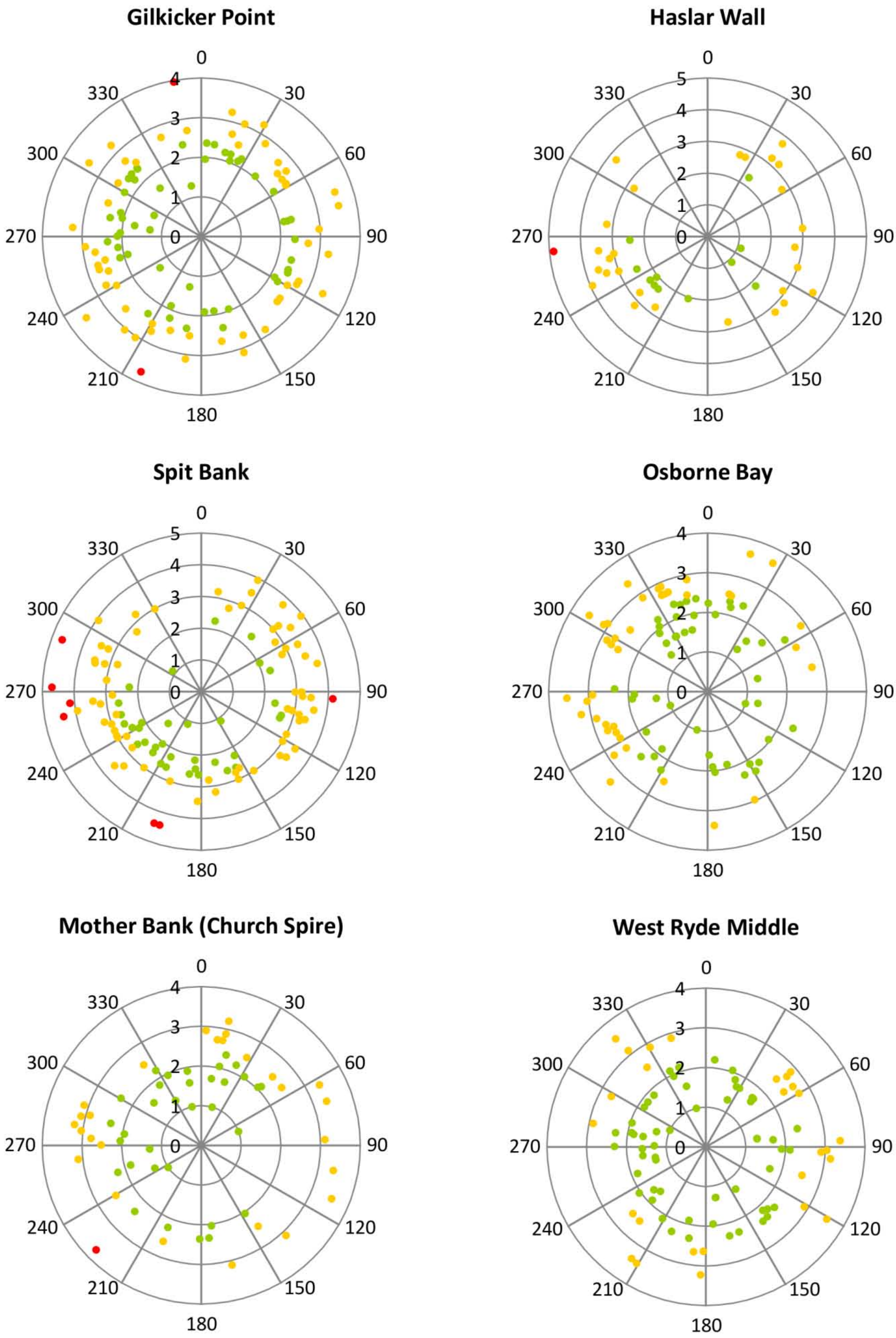


Figure XI.18b: Polar plots of log10 E. coli results (MPN/100g) in against high/low tidal state for native oyster RMPs

A tendency for higher results around low water was seen at Calshot, Yarmouth West and Newtown River Mouth. A tendency for higher results on the ebb tide was seen at Browndown, Gillkicker and Mother Bank Church Spire. No clear patterns were apparent at South West Sewer Outfall, North West Sewer Outfall, Haslar, Spit Bank or West Ryde Middle.

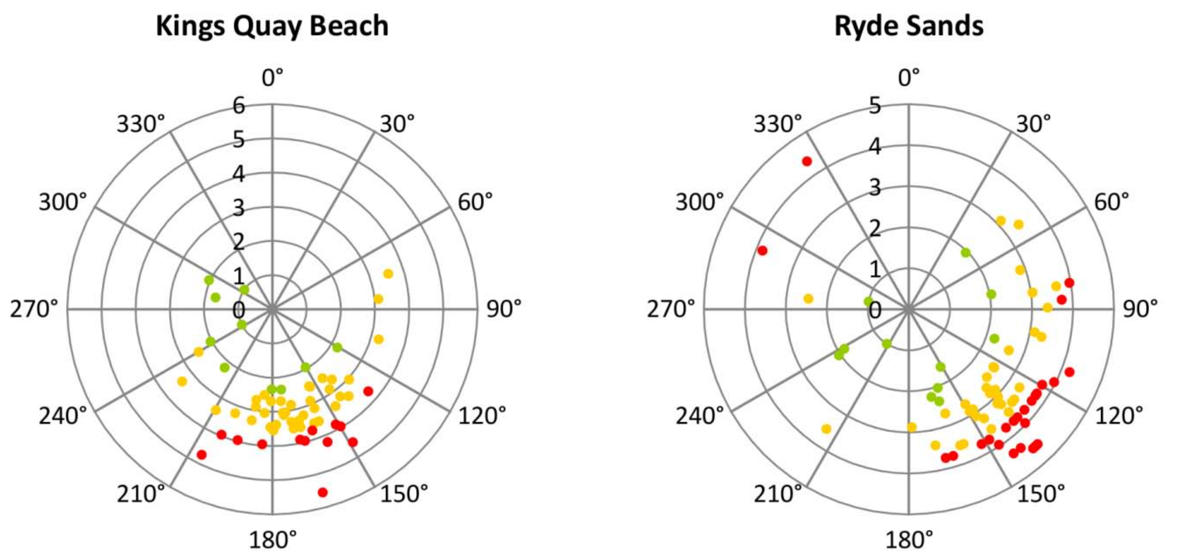


Figure XI.19: Polar plots of log10 E. coli results (MPN/100g) in against high/low tidal state for cockle RMPs

No patterns were apparent for cockles, and sampling was targeted towards lower states of the tide when the shellfish are uncovered.

Figure XI.20 and Figure XI.21 present polar plots of log10 *E. coli* results against the spring neap tidal cycle for each RMP. Full/new moons occur at 0º, and half moons occur at 180º, and the largest (spring) tides occur about 2 days after the full/new moon, or at about 45º, then decrease to the smallest (neap tides) at about 225º, then increase back to spring tides. Results of 230 *E. coli* MPN/100g or less are plotted in green, those from 231 to 4600 are plotted in yellow, and those exceeding 4600 are plotted in red.

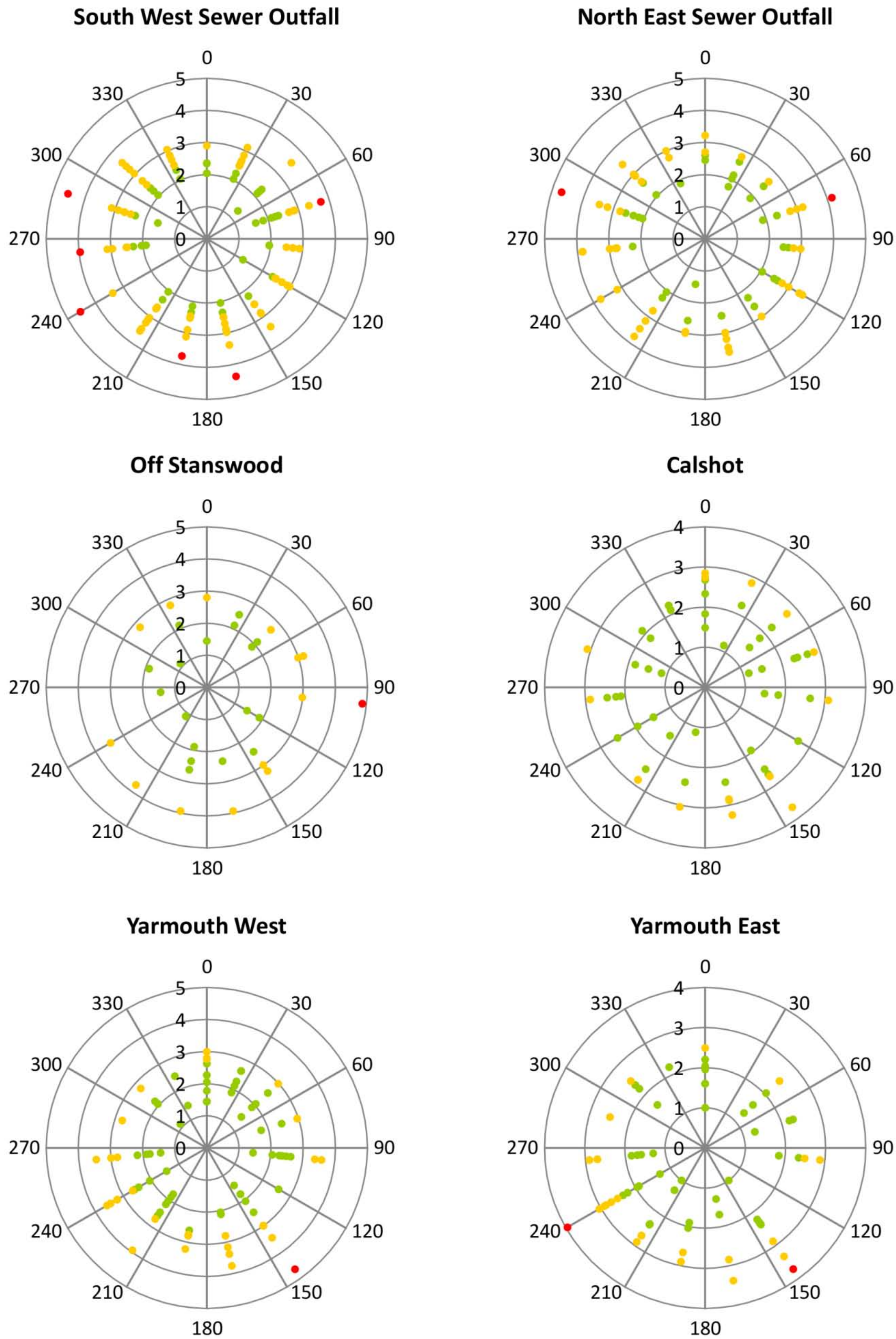


Figure XI.20a: Polar plot of log10 E. coli results (MPN/100g) against spring/neap tidal state for native oyster RMPs

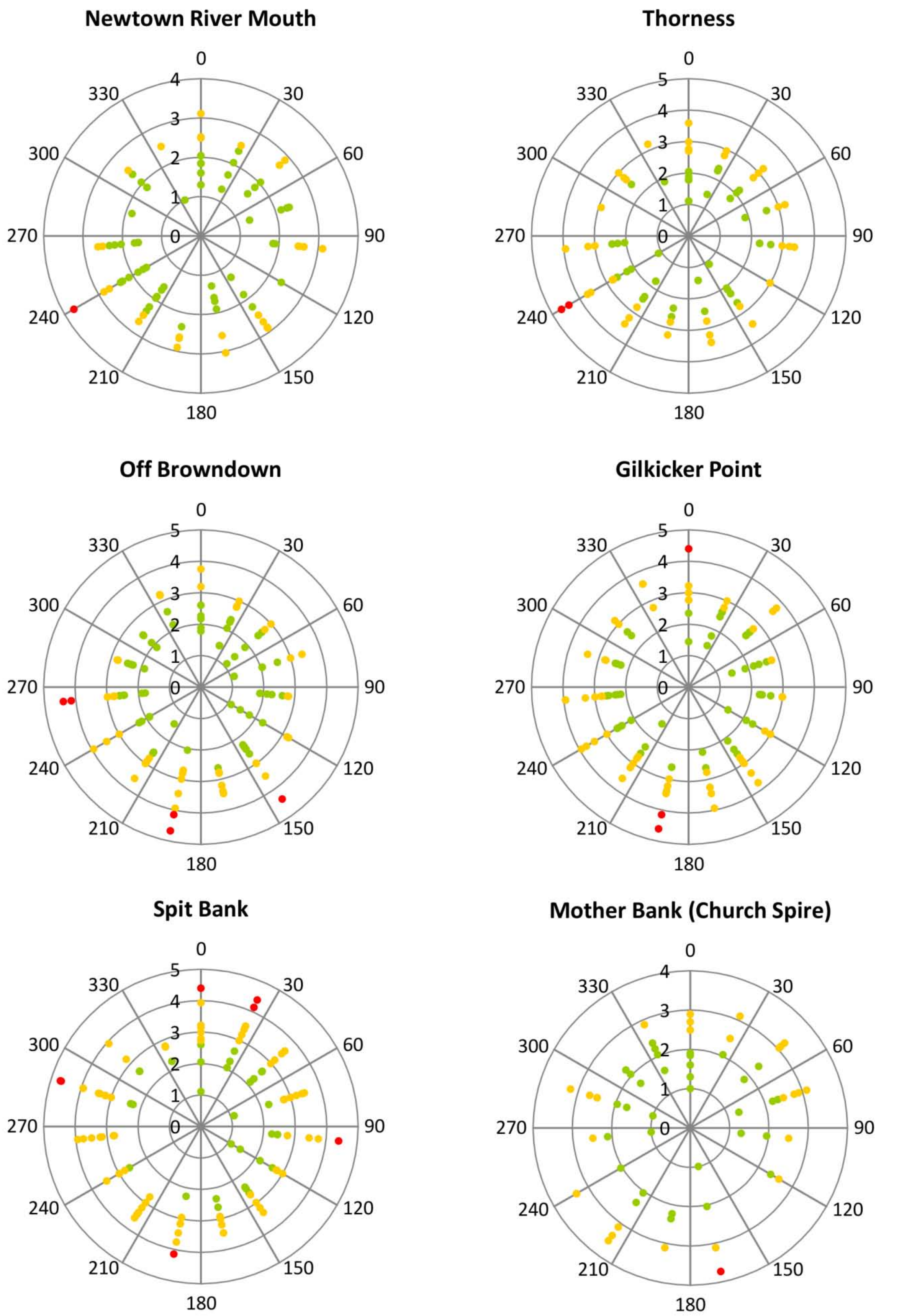


Figure XI.20b: Polar plot of log10 E. coli results (MPN/100g) against spring/neap tidal state for native oyster RMPs

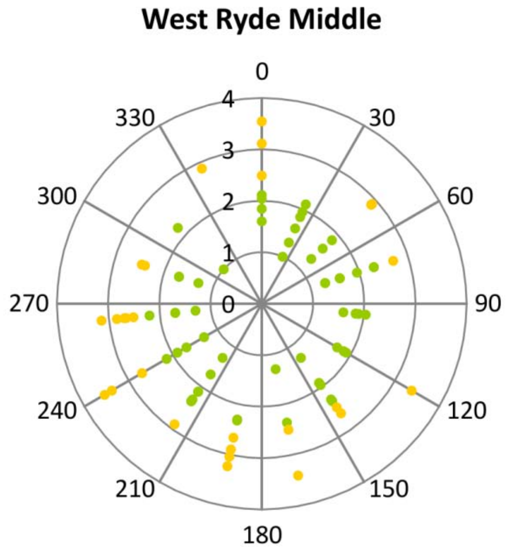


Figure XI.20c: Polar plot of log10 E. coli results (MPN/100g) against spring/neap tidal state for native oyster RMPs

At most of the native oyster RMPs, higher results tended to occur around the neap tide where less water is exchanged, although this pattern is not apparent for all RMPs.

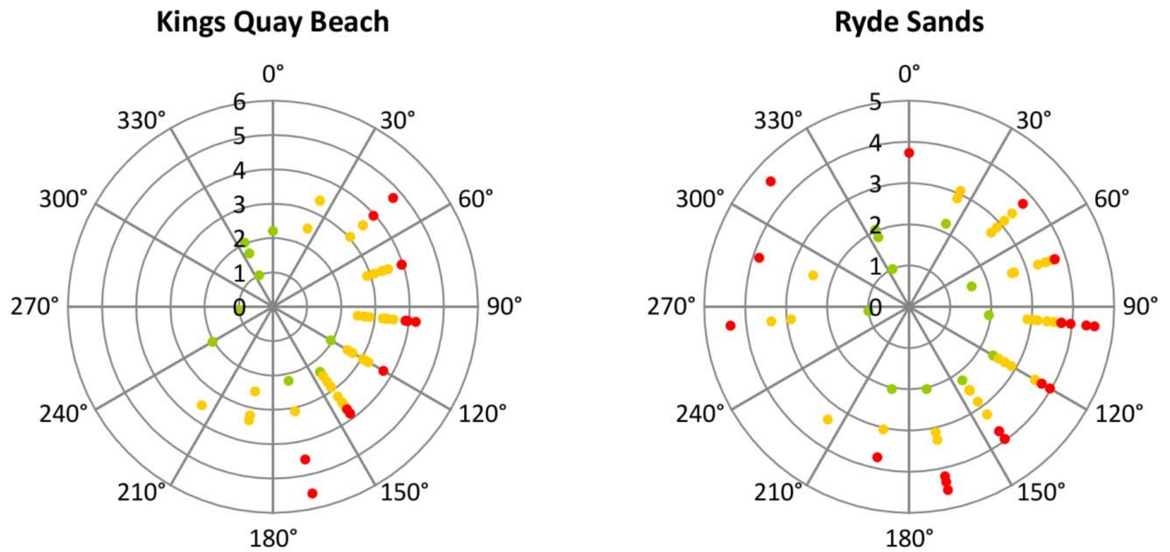


Figure XI.21: Polar plot of log10* E. coli *results (MPN/100g) against spring/neap tidal state for cockle RMPs

Tentatively there is a tendency for lower results as tide size increases from neaps to springs at Kings Quay. No patterns are apparent at Ryde Sands.

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 Stem Lane weather station (Appendix II for details) over various periods running up to sample collection. These are presented in Table XI.5, and statistically significant correlations ($p<0.05$) are highlighted in yellow.

Table XI.5: Spearman's Rank correlations between rainfall recorded at Stem Lane and shellfish hygiene results

			24 hour periods prior to sampling							Total prior to sampling over					
Species	**Site**	**n**	**1 day**	**2 days**	**3 days**	**4 days**	**5 days**	**6 days**	**7 days**	**2 days**	**3 days**	**4 days**	**5 days**	**6 days**	**7 days**
Native oysters	South West Sewer Outfall	110	-0.044	0.035	0.082	-0.102	0.068	0.220	0.126	0.050	0.121	0.084	0.127	0.193	0.178
	North East Sewer Outfall	76	0.123	0.103	0.230	0.094	0.207	0.277	0.286	0.155	0.297	0.303	0.359	0.419	0.412
	West Lymington River	79	0.170	0.229	0.095	-0.116	0.214	0.170	0.267	0.235	0.230	0.189	0.244	0.246	0.268
	East Lymington River	105	0.093	0.185	0.183	0.049	0.214	0.284	0.290	0.193	0.220	0.170	0.210	0.279	0.313
	Off Lepe	112	0.115	0.229	0.464	0.284	0.256	0.293	0.307	0.270	0.392	0.455	0.465	0.452	0.465
	Stanswood	79	0.072	0.091	0.382	0.214	0.28	0.110	0.148	0.134	0.240	0.297	0.309	0.287	0.286
	Off Stanswood	32	0.121	0.461	0.539	0.309	0.178	0.340	0.228	0.434	0.523	0.494	0.505	0.504	0.497
	Calshot	57	-0.056	-0.151	0.080	0.203	0.174	0.285	0.238	-0.147	-0.086	0.052	0.120	0.150	0.167
	Totland Bay Pier	63	0.144	0.208	0.319	0.303	0.233	0.203	-0.099	0.211	0.336	0.374	0.393	0.433	0.412
	Yarmouth West	87	0.067	0.325	0.291	0.310	0.186	0.080	0.104	0.234	0.321	0.401	0.395	0.424	0.412
	Yarmouth East	69	-0.073	0.399	0.081	0.281	0.202	0.077	0.035	0.207	0.249	0.296	0.297	0.350	0.350
	Newtown River Mouth	91	-0.002	0.365	0.256	0.299	0.161	0.093	-0.010	0.211	0.292	0.347	0.337	0.345	0.320
	Saltmead Ledge	66	0.218	0.385	0.292	0.315	0.323	0.024	0.113	0.415	0.492	0.498	0.514	0.489	0.480
	Thorness	86	0.166	0.432	0.320	0.375	0.290	0.276	0.096	0.321	0.378	0.457	0.440	0.481	0.446
	Off Browndown	113	-0.079	0.147	0.298	0.247	0.097	0.179	0.090	0.061	0.183	0.284	0.304	0.321	0.306
	Gilkicker Point	113	-0.080	-0.010	0.191	0.126	-0.037	0.175	0.248	-0.025	0.070	0.159	0.154	0.141	0.203
	Haslar Wall	39	-0.075	0.259	0.239	0.132	-0.194	-0.110	-0.192	0.133	0.179	0.221	0.033	0.004	-0.041
	Spit Bank	116	-0.157	0.208	0.384	0.269	0.108	0.115	0.082	0.065	0.220	0.247	0.251	0.233	0.210
	Osborne Bay	88	0.192	0.317	0.415	0.207	0.006	0.100	0.012	0.287	0.379	0.410	0.321	0.318	0.301
	Kings Quay	88	0.258	0.257	0.337	0.259	0.086	0.228	0.121	0.273	0.325	0.374	0.321	0.358	0.364
	Mother Bank (Church Spire)	61	0.177	0.204	0.35	0.184	0.125	0.155	0.086	0.201	0.226	0.298	0.308	0.371	0.376
	West Ryde Middle	84	-0.035	-0.062	0.295	0.457	0.241	0.290	0.183	-0.065	0.089	0.344	0.382	0.402	0.386
	East Ryde Middle	35	-0.114	-0.273	0.195	0.158	-0.076	0.003	0.078	-0.226	-0.084	0.031	0.114	0.095	0.137
	Ryde Pier	110	0.031	0.225	0.361	0.298	0.175	0.343	0.170	0.176	0.280	0.401	0.432	0.459	0.428
Cockles	Kings Quay Beach	62	0.308	0.410	0.296	0.347	0.075	0.161	-0.093	0.415	0.454	0.443	0.393	0.417	0.369
	Ryde Sands	71	0.164	0.208	0.367	0.211	0.186	0.313	0.182	0.289	0.436	0.393	0.398	0.405	0.431
Razor clams	Kings Quay Beach	21	0.440	0.166	0.150	0.195	0.260	0.110	0.146	0.408	0.273	0.359	0.372	0.463	0.481
	Ryde Sands	11	0.253	-0.296	0.270	0.418	0.157	0.156	0.331	-0.058	-0.014	0.365	0.296	0.375	0.427

No influence of rainfall was detected at Haslar Wall, East Ryde Middle or Ryde Sands (razors) although the latter was only sampled on 11 occasions and an influence of rainfall on cockles was found here. The influence of rainfall typically peaked around 3 days after the event, with some exceptions in the north west Solent (South West Sewer Outfall to East Lymington River) where is was less consistent and more delayed.

APPENDIX XII
SHORELINE SURVEY

Date (time): 29/01/2013 (08:30 – 16:00 GMT)
30/01/2013 (09:00 – 16:00 GMT)
31/01/2013 (09:00 – 11:30 GMT)

Cefas Officers: David Walker (Mainland), Alastair Cook (North-west Isle of Wight), Rachel Parks (North-east Isle of Wight)

Local Enforcement Authority Officers: Dale Bruce (New Forest DC, 29/01/2013 & 31/01/2013), Claire Ferry (Gosport DC, 30/01/2013 only), Karen Brett (Fareham DC, 30/01/2013 only), David Fentum (IoW DC, 29/01/2013 – 30/01/2013), James Howe (IoW DC, 29/01/2013 – 30/01/2013).

Area surveyed: The Solent (Figure XII.1)

Weather (10:00GMT at Lee-on-Solent):

29th January 2013 - Wind 250° 55 km/h, temp 10.5°C, Rain
30th January 2013 - Wind 260° 44 km/h, temp 8.9°C, Clear
31st January 2013 - Wind 270° 46 km/h, temp 9.2°C, Clear

Tidal predictions for Lee-on-Solent (Admiralty EasyTide):

Tue 29 Jan			
HW	LW	HW	LW
00:24	05:38	12:34	17:58
4.4 m	1.1 m	4.4 m	1.0 m

Wed 30 Jan			
HW	LW	HW	LW
00:58	06:11	13:08	18:30
4.4 m	1.1 m	4.4 m	1.0 m

Thu 31 Jan			
HW	LW	HW	LW
01:32	06:45	13:43	19:04
4.4 m	1.1 m	4.4 m	1.0 m

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 referenced in Table XII.1 are presented in Figure XII.6 to Figure XII.24.

The shoreline survey was conducted over 3 days with Cefas officers surveying separate areas simultaneously. Most of the survey was conducted on foot, except for the stretch of coast directly east of Cowes on the Isle of Wight, which was surveyed by boat. This was due to limited access to the coastline here. Limited access was due in part to much of this coastline being privately owned and also because of physically impassable cliffs. One CTD measurement was taken in the mouth of the Beaulieu River, however due to bad weather the remaining area between the Beaulieu and Lymington Rivers was cancelled. The majority of this coastline is privately owned and permission could not be gained to access large stretches of the coast. The decision was taken to survey this area by boat, however gale force winds on the survey day meant that this was not possible.

All significant surface water inputs to the shoreline were sampled and measured where possible (Table XII.2).

Description of Fishery

A full shellfish stock survey was beyond the scope of the shoreline survey, and this report only presents observations made during the survey. Much of the Solent is classified for harvesting native oysters, although no live animals were observed during the survey. On the north coast adjacent to the New Forest dead shell of cockles, mussels and oysters were observed.

Sources of contamination

Sewage discharges

The locations of several intermittent and private outfalls were confirmed as well as the Pennington WWTW outfall (observation 30). There were also several pipes discharging that are not listed on the EA permit database. These discharges are presumed to carry surface water and were sampled where possible. Many outfalls were not flowing, which given that the preceding weeks had high precipitation resulting in a high water table, indicated that heavy flow from these sources is likely to be uncommon.

The Hook Park intermittent outfall (observation 19) located on the eastern shore of the mouth of Southampton Water had a very strong sewage odour, but was below the tide and could not be sampled. According to the local authority there have been several discharges from this outfall recently.

Freshwater inputs

The main freshwater inputs to the Solent are the Lymington and Beaulieu Rivers, the rivers Test, Itchen and Hamble (which discharge into Southampton Water), the River Meon, and the River Medina and Eastern Yar (on the Isle of Wight). These inputs were too large to sample directly (except for the River Meon) and should therefore be treated as significant sources of contamination. Several other smaller streams were observed and sampled where possible.

Many of the streams on the Isle of Wight had high bacterial loadings. This was particularly true of Gurnard Bay and Thorness Bay (observations 55-60) where many of the stream had bacterial loadings in the regions of 10^{12} E. coli per day, and one (observation 55) discharging 2.2×10^{13} E. coli per day. The only freshwater input on the mainland to have loadings of higher than 10^{12} E. coli per day was the Alver River (observation 12).

Boats and Shipping

The Solent is a very popular area for recreational boating and as a result there are several marinas and moorings throughout the area.

Livestock

Only ponies and alpacas were directly observed during the shoreline survey. However a manure heap was observed on the Isle of Wight (observation 40) and a strong manure odour was obsevered at Thorness Bay (observation 60), which was possibly the source of the high *E. coli* concentrations (280,000 cfu/100ml) found here.

Wildlife

There were several moderately sized flocks of birds observed at various locations throughout the Solent.

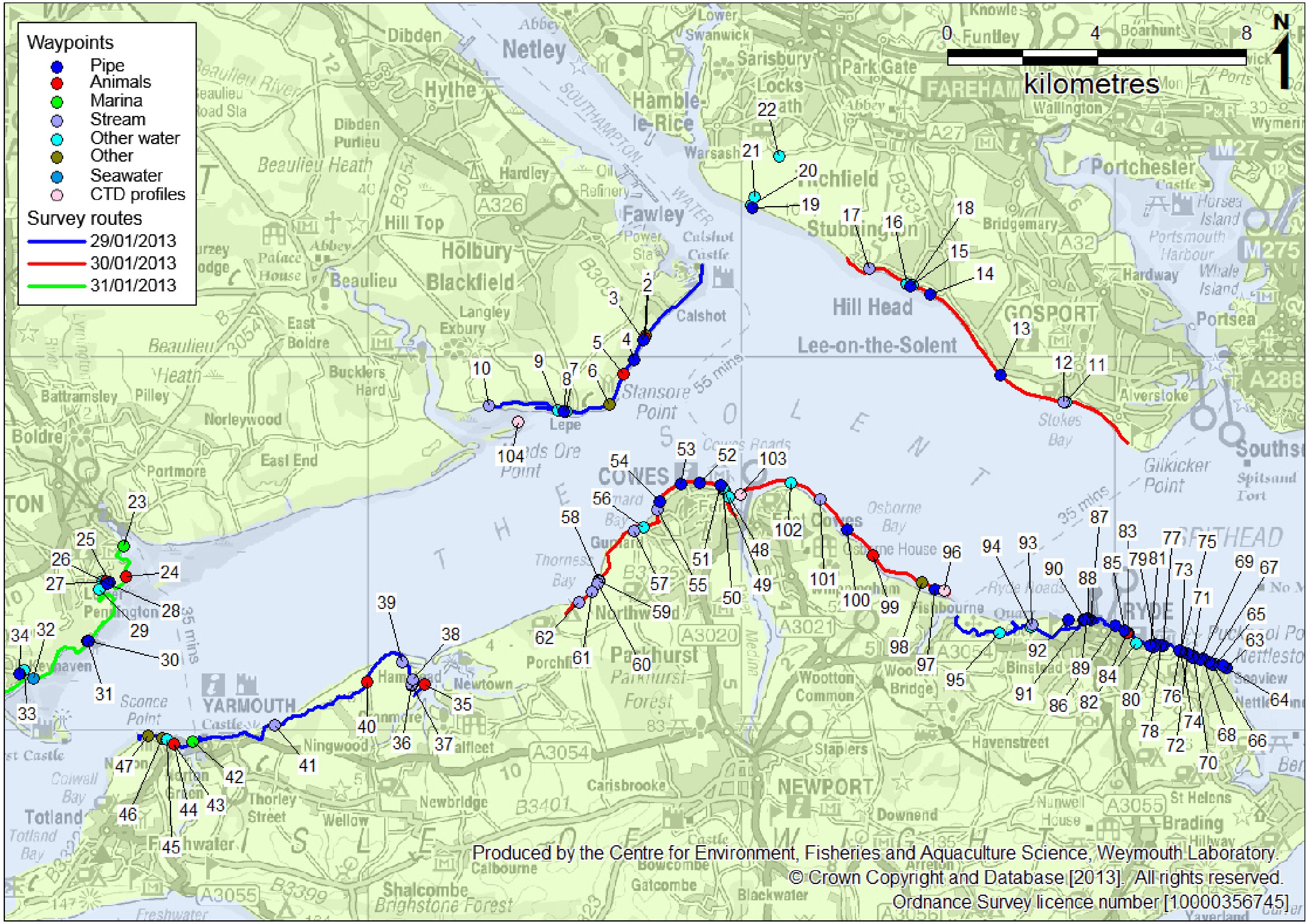


Figure XII.1: Locations of shoreline observations (see Table XII.1 for details)

Table XII.1 Details of Shoreline Observations

Number	Date & Time	NGR	Image	Type	Description
1	29/01/2013 10:00	SU 47433 00561		Other	Fence & surface water runoffs (sample NWS01)
2	29/01/2013 10:07	SU 47390 00498		Animal	Burrows
3	29/01/2013 10:08	SU 47356 00442		Pipe	Pipe not flowing
4	29/01/2013 10:18	SZ 47102 99898		Pipe	Pipe (large, ~60cm diameter), end below tide (Cadland House private discharge)
5	29/01/2013 10:25	SZ 46828 99528		Animal	Dead shell (cockles, mussels, oysters, slipper limpets)
6	29/01/2013 10:41	SZ 46438 98718		Other	Fence (barbed wire)
7	29/01/2013 11:01	SZ 45279 98543	Figure XII.6	Other water	Sluice (not flowing). Sample taken land side (sample NWS02)
8	29/01/2013 11:03	SZ 45212 98539		Pipe	Small pipe, no flow
9	29/01/2013 11:09	SZ 45057 98566		Other water	Possible inspection cover (Coastguard Cottages private discharge)
10	29/01/2013 14:27	SZ 43213 98685		Stream	Creek from pond (sample NWS03)
11	30/01/2013 09:55	SZ 58691 98783		Other water	Ground water flow (sample NES01)
12	30/01/2013 10:03	SZ 58630 98772	Figure XII.7	Stream	Alver River (No. 2 Battery) (sample NES02)
13	30/01/2013 10:37	SZ 56935 99489		Pipe	Pipe (Queens road CSO)
14	30/01/2013 11:47	SU 55026 01657		Pipe	Outfall, below tide (Saltern Road CSO)
15	30/01/2013 11:58	SU 54513 01883		Pipe	Outfall, below tide (Crofton Lane CSO)
16	30/01/2013 12:02	SU 54416 01952	Figure XII.8	Other water	Hose pipe draining pond overflow from private residence(5 Hill Head Road) (sample NES03)
17	30/01/2013 12:31	SU 53425 02354		Stream	Meon River mouth and quay (sample NES04)
18	30/01/2013 13:29	SU 54555 01925		Other water	Pumping station (Salterns Lane)
19	30/01/2013 15:32	SU 50273 03990	Figure XII.9	Pipe	Hook Park Outlet #2 (obvious sewage smell in the air). Below tide.
20	30/01/2013 15:35	SU 50241 04041		Other water	Possible inspection cover for Hook Park outlet
21	30/01/2013 15:38	SU 50336 04269		Other water	Pumping station (Workmans Lane)
22	30/01/2013 15:49	SU 51004 05376		Other water	Southern Water enclosure & stream/runoff (sample NES05)
23	31/01/2013 08:59	SZ 33428 94934		Marina	Lymington marina (sample L01)
24	31/01/2013 09:14	SZ 33494 94103		Animal	~200 birds (various species)
25	31/01/2013 09:25	SZ 33051 93956	Figure XII.10	Pipe	Pipe - Not possible to measure flow. ~50cm diameter (sample L02)
26	31/01/2013 09:30	SZ 32990 93930		Pipe	Drainage pipe
27	31/01/2013 09:31	SZ 32956 93990		Animal	2 ponies
28	31/01/2013 09:39	SZ 32868 93979	Figure XII.11	Other water	Sluice (sample L03)
29	31/01/2013 09:44	SZ 32763 93755		Other water	Sluice (flap valve #8), closed
30	31/01/2013 10:24	SZ 32502 92371		Pipe	Start of pipeline (Pennington WWTW)
31	31/01/2013 10:25	SZ 32455 92388		Other water	Inspection cover/vent for 30

32	31/01/2013 10:52	SZ 31027 91392	Figure XII.12	Seawater	Sea near Keyhaven Marina (sample L04)
33	31/01/2013 10:57	SZ 30782 91585		Other water	Sluice (not accessible)
34	31/01/2013 11:01	SZ 30646 91519	Figure XII.13	Pipe	Small pipe valves - possibly draining marshes under road
35	29/01/2013 10:01	SZ 41492 91218		Animal	~50 geese
36	29/01/2013 10:09	SZ 41162 91185		Stream	Stream (sample Yar1)
37	29/01/2013 10:14	SZ 41151 91224		Stream	Stream (sample Yar2)
38	29/01/2013 10:20	SZ 41166 91347		Stream	Stream (sample Yar3)
39	29/01/2013 10:34	SZ 40895 91829		Stream	Stream (sample Yar4)
40	29/01/2013 11:05	SZ 39941 91294	Figure XII.14	Animal	Manure heap in farm yard
41	29/01/2013 11:54	SZ 37484 90113		Stream	Stream (sample Yar5)
42	29/01/2013 12:41	SZ 35287 89677		Marina	Yarmouth marina
43	29/01/2013 12:50	SZ 34771 89616	Figure XII.15	Animal	Lots of birds on estuary. 10 alpacas
44	29/01/2013 12:51	SZ 34767 89632		Other water	PS enclosure
45	29/01/2013 12:56	SZ 34598 89747	Figure XII.16	Other water	Stream inspection cover, appears to have overflowed. Odour, rag
46	29/01/2013 13:00	SZ 34467 89765	Figure XII.17	Other	Mysterious green cylinder (concrete)
47	29/01/2013 13:08	SZ 34081 89827		Other	Cotton buds in tide line between here and previous waypoint
48	30/01/2013 09:20	SZ 49657 96237		Other water	Harbour Lights SW pumping station
49	30/01/2013 09:25	SZ 49524 96440		Other	Next to public toilets
50	30/01/2013 09:28	SZ 49504 96496		Other water	Inspection cover on beach (The Parade PS)
51	30/01/2013 09:30	SZ 49430 96539		Pipe	Buried cast iron pipe
52	30/01/2013 09:38	SZ 48875 96616		Pipe	Egypt point PS. Red buoy just off beach
53	30/01/2013 09:46	SZ 48358 96579		Pipe	Surface water outfall (sample Cowes1)
54	30/01/2013 10:02	SZ 47785 96109	Figure XII.18	Pipe	Pipe under rock groyne. PS and storm tanks (Woodvale/Gurnard headwork PS)
55	30/01/2013 10:06	SZ 47727 95904		Stream	Culverted stream (sample Cowes2)
56	30/01/2013 10:25	SZ 47364 95439		Other water	PS
57	30/01/2013 10:36	SZ 47108 95342		Stream	Stream (sample Cowes3)
58	30/01/2013 11:27	SZ 46173 93997		Stream	Stream (sample Cowes4)
59	30/01/2013 11:31	SZ 46171 93974		Stream	Stream (sample Cowes4a)
60	30/01/2013 11:34	SZ 46133 93908		Stream	Stream (sample Cowes7) – possible manure contamination (odour)
61	30/01/2013 11:42	SZ 45967 93704		Stream	Stream (sample Cowes5)
62	30/01/2013 12:00	SZ 45634 93419		Stream	Stream (sample Cowes6)
63	29/01/2013 08:35	SZ 62961 91673	Figure XII.19	Pipe	Pipe – submerged (Seaview WPS)
64	29/01/2013 08:41	SZ 62881 91735		Pipe	Pipe - not flowing
65	29/01/2013 08:46	SZ 62692 91751	Figure XII.20	Other water	Land drainage from under steps (sample FW1)
66	29/01/2013 08:52	SZ 62587 91768	Figure XII.21	Pipe	Pipe- Flowing (sample FW2) (Salterns CSO)
67	29/01/2013 09:02	SZ 62505 91818		Pipe	Pipe- Flowing (sample FW3)

68	29/01/2013 09:10	SZ 62337 91897		Pipe	Pipe - Flowing (sample FW4)
69	29/01/2013 09:14	SZ 62269 91881	Figure XII.22	Pipe	Pipe - Flowing (sample FW5)
70	29/01/2013 09:23	SZ 62108 91960		Pipe	Pipe - Flowing (sample FW6)
71	29/01/2013 09:32	SZ 62067 91956		Pipe	Pipe - Flowing (sample FW7)
72	29/01/2013 09:40	SZ 61952 92039		Pipe	Pipe –Submerged (Springvale CSO)
73	29/01/2013 09:45	SZ 61769 92104		Pipe	Pipe -Submerged
74	29/01/2013 09:48	SZ 61760 92103		Pipe	Pipe - Not Flowing
75	29/01/2013 09:48	SZ 61766 92102		Pipe	Pipe - Flowing (sample FW8)
76	29/01/2013 09:50	SZ 61706 92135		Pipe	Pipe - Not Flowing
77	29/01/2013 09:58	SZ 61284 92247		Pipe	Pipe - Flowing
78	29/01/2013 10:00	SZ 61210 92249		Pipe	Pipes - Flowing - Land drainage (every 6 m)
79	29/01/2013 10:03	SZ 61057 92285	Figure XII.23	Pipe	Pipe x2 - Flowing
80	29/01/2013 10:09	SZ 61027 92225		Pipe	Pipe - Flowing (sample FW9)
81	29/01/2013 10:17	SZ 60942 92249		Pipe	Pipes - Flowing - Land drainage (every 6 m)
82	29/01/2013 10:27	SZ 60555 92327		Other water	Sewage Pumping Station
83	29/01/2013 10:35	SZ 60347 92615		Other	Dog Ban Sign
84	29/01/2013 10:36	SZ 60317 92609		Animal	Lake adjacent to beach - 200x ducks and swans
85	29/01/2013 10:38	SZ 60255 92661		Pipe	Outfall - Flowing - partially submerged by tide
86	29/01/2013 10:44	SZ 59991 92796		Pipe	Outfall - Flowing - submerged by tide
87	29/01/2013 11:02	SZ 59349 92950		Pipe	Pipe - Not Flowing
88	29/01/2013 11:04	SZ 59285 92984	Figure XII.24	Pipe	Pipe
89	29/01/2013 11:05	SZ 59251 92971		Pipe	Pipe
90	29/01/2013 11:08	SZ 59174 92952		Pipe	Pipe - Not Flowing
91	29/01/2013 11:09	SZ 59161 92931		Other water	Sewage Pumping Station
92	29/01/2013 11:24	SZ 58727 92936		Pipe	Outfall - Flowing - partially submerged by tide (Augusta Road CSO)
93	29/01/2013 12:00	SZ 57764 92823		Stream	Stream (sample FW10)
94	29/01/2013 12:09	SZ 57748 92759		Other water	Pumping Station (Binstead WPS), discharging to 93
95	29/01/2013 12:38	SZ 56897 92607		Other water	Pumping Station
96	30/01/2013 09:55	SZ 55405 93724		CTD	CTD measurement taken
97	30/01/2013 10:05	SZ 55152 93776		Pipe	Pipe – Flowing (Oaklawn, Woodside private discharge)
98	30/01/2013 10:08	SZ 54830 93964		Other	Woodside Beach Caravan Park (problems with raw discharge previously)
99	30/01/2013 10:19	SZ 53518 94673		Animal	Birds x 10
100	30/01/2013 10:25	SZ 52814 95355		Pipe	Pipe - Flowing
101	30/01/2013 10:31	SZ 52078 96178		Stream	Stream
102	30/01/2013 10:37	SZ 51309 96622		Other water	Land drainage
103	30/01/2013 10:48	SZ 49968 96288		CTD	CTD measurement taken

104	30/01/2013 09:25	SZ 44015 98243	CTD	CTD measurement taken

Castaway CTD Measurements

Conductivity (practical salinity scale), temperature (degrees Celsius) and depth (metres) [CTD] measurements were taken at the beginning and the end of the boat survey, between Fishbourne and East Cowes on the 30/01/2013. A CTD measurement was also taken in the entrance to the Beaulieu estuary, however due to bad weather conditions the remainder of the survey, to the mouth of the Lymington River had to be cancelled. Temperature and salinity profiles for these three locations are shown in Figures XII. 2 – Figure XII.4.

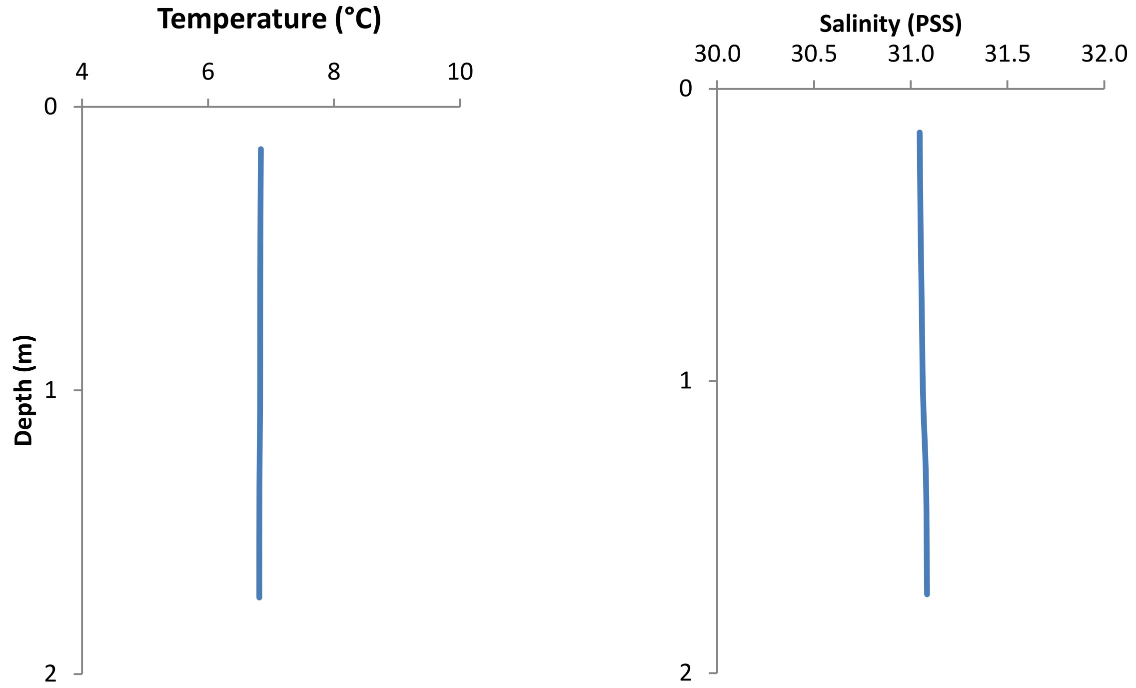


Figure XII.2 Temperature and salinity profiles west of Wootton Creek (observation 96)

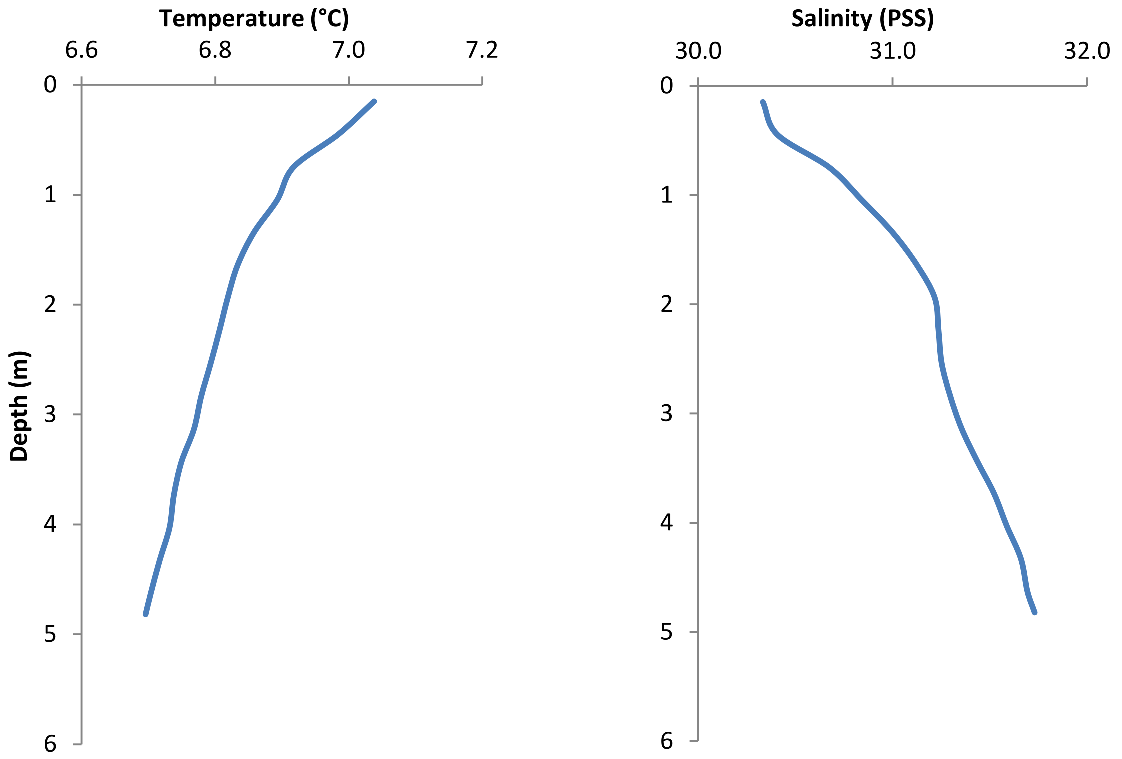


Figure XII.3 Temperature and salinity profiles at mouth of the Medina (observation 103)

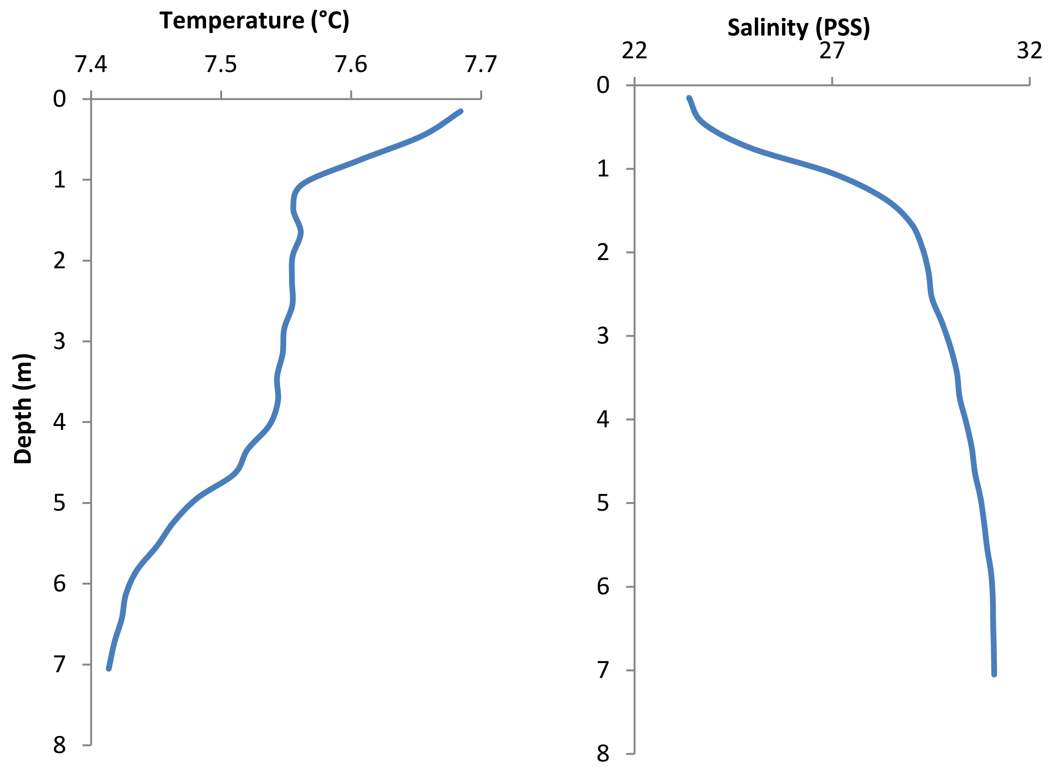


Figure XII.4 Temperature and salinity profiles at mouth of the Beaulieu River (observation 104)

West of Wootton Creek the thermocline and halocline were uniform through the shallow water column 6.8 °C and at 31.0 - 31.1 PSS suggesting it is well mixed. The

CTD profiles in the mouth of the Medina and Beaulieu rivers show a decrease in temperature and an increase in salinity with depth. This is more considerable in the Beaulieu where the temperature drops by 0.3 °C in just under 8 m and the salinity increases from 23.4 – 31.1 PSS. Both show a slight stratification with less saline water in the top layer (up to around 1 m) and more saline water in the lower layers. Freshwater may contain high concentrations of microbiological contamination from land run-off and sewage discharges to non-tidal waters or if relatively uncontaminated provide dilution of contaminated saline waters. Consequently there could be a potential difference in the microbiological concentrations in the top layer and bottom layers in the mouths of the two rivers.

Sample results

Freshwater inputs were sampled and spot discharge measurements taken, to give spot estimates of their *E. coli* loadings (Table XII.2 and Figure XII.5). Due to the extensive microbiological monitoring history of the area shellfish sampling was not considered necessary.

Table XII.2 Water sample E. coli results and estimated stream loadings

Sample	Time	NGR	*E. coli* (cfu/100ml)	Flow (m^3/day)	*E. coli* loading (cfu/day)
NWS01	29/01/2013 10:00	SU 47433 00561	7100	1039.6	7.38×10^{10}
NWS02	29/01/2013 11:01	SZ 45279 98543	110		
NWS03	29/01/2013 14:27	SZ 43213 98685	380	2709.9	1.03×10^{10}
NES01	30/01/2013 09:55	SZ 58691 98783	5	2231.7	1.12×10^{8}
NES02	30/01/2013 10:03	SZ 58630 98772	4000	121888.8	4.88×10^{12}
NES03	30/01/2013 12:02	SU 54416 01952	5	93.7	4.69×10^{6}
NES04	30/01/2013 12:31	SU 53425 02354	490		
NES05	30/01/2013 15:49	SU 51004 05376	170	2980.8	5.07×10^{9}
L01	31/01/2013 08:59	SZ 33428 94934	1100		
L02	31/01/2013 09:25	SZ 33051 93956	3200		
L03	31/01/2013 09:39	SZ 32868 93979	7300	6179.8	4.51×10^{11}
L04	31/01/2013 10:52	SZ 31027 91392	2400		
Yar1	29/01/2013 10:09	SZ 41162 91185	600	5815.8	3.49×10^{10}
Yar2	29/01/2013 10:14	SZ 41151 91224	600	2269.3	1.36×10^{10}
Yar3	29/01/2013 10:20	SZ 41166 91347	560	870.9	4.88×10^{9}
Yar4	29/01/2013 10:34	SZ 40895 91829	1200	9227.5	1.11×10^{11}
Yar5	29/01/2013 11:54	SZ 37484 90113	1600	1437.3	2.30×10^{10}
Cowes1	30/01/2013 09:46	SZ 48358 96579	710	738.7	5.24×10^{9}
Cowes2	30/01/2013 10:06	SZ 47727 95904	220000	10152.3	2.23×10^{13}
Cowes3	30/01/2013 10:36	SZ 47108 95342	3300	101751.6	3.36×10^{12}
Cowes4	30/01/2013 11:27	SZ 46173 93997	720	2073.3	1.49×10^{10}
Cowes 4a	30/01/2013 11:31	SZ 46171 93974	720	703.0	5.06×10^{9}
Cowes7	30/01/2013 11:34	SZ 46133 93908	280000	1223.4	3.43×10^{12}
Cowes5	30/01/2013 11:42	SZ 45967 93704	910	59947.8	5.46×10^{11}
Cowes6	30/01/2013 12:00	SZ 45634 93419	650	51757.1	3.36×10^{11}
FW1	29/01/2013 08:46	SZ 62692 91751	2300		
FW2	29/01/2013 08:52	SZ 62587 91768	10000	30.0	3.00×10^{9}
FW3	29/01/2013 09:02	SZ 62505 91818	1200		
FW4	29/01/2013 09:10	SZ 62337 91897	1600		
FW5	29/01/2013 09:14	SZ 62269 91881	300	6478.9	1.94×10^{10}
FW6	29/01/2013 09:23	SZ 62108 91960	41000	518.9	2.13×10^{11}
FW7	29/01/2013 09:32	SZ 62067 91956	91000	130.9	1.19×10^{11}
FW8	29/01/2013 09:48	SZ 61766 92102	4400		
FW9	29/01/2013 10:09	SZ 61027 92225	1300	1997.3	2.60×10^{10}
FW10	29/01/2013 00:00	SZ 57764 92823	7500	18740.2	1.41×10^{12}

*Numbers of *E. coli* per day introduced to coastal waters from each input, calculated from spot gauging of discharges and corresponding water sample *E. coli* results.

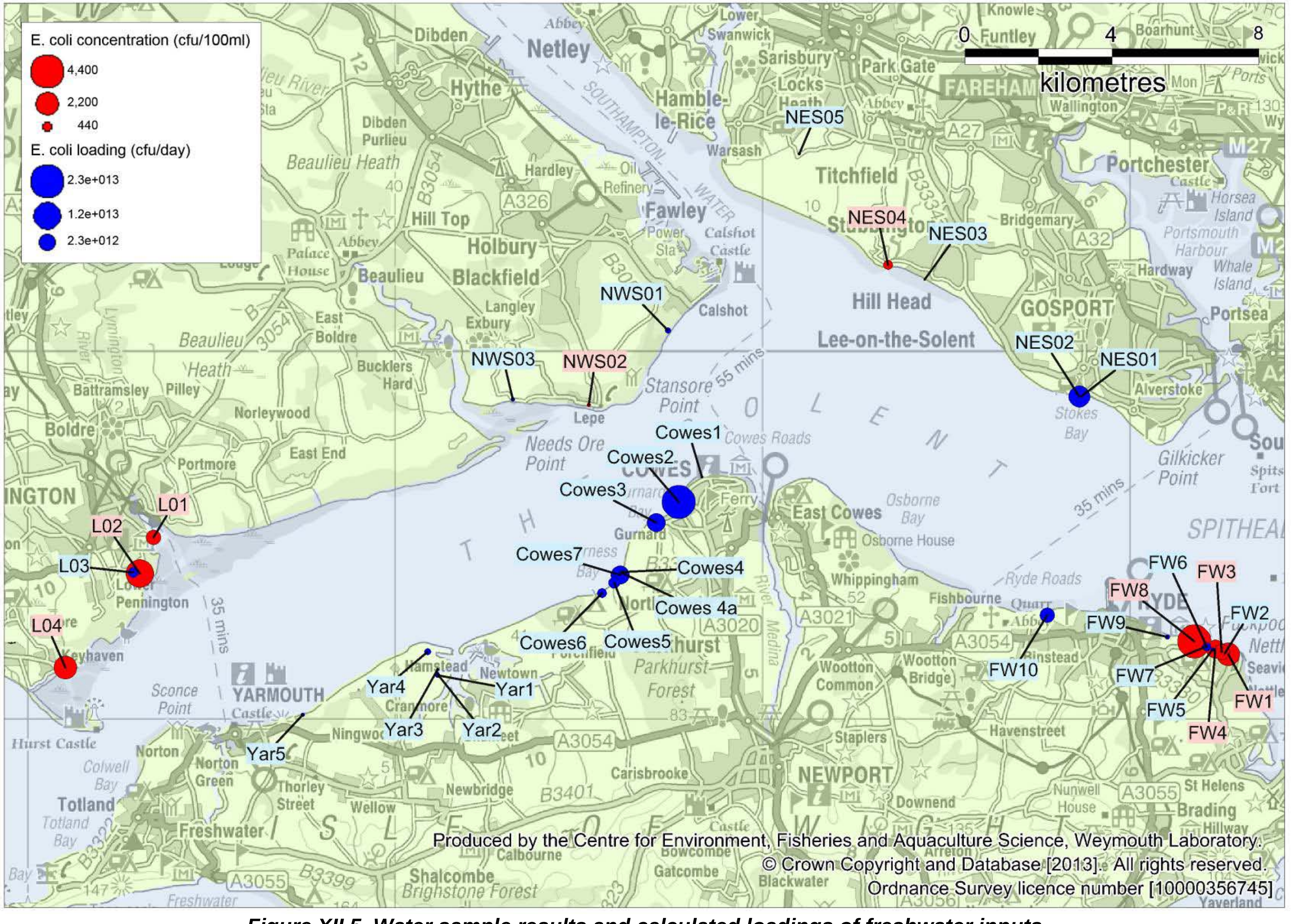


Figure XII.5 Water sample results and calculated loadings of freshwater inputs

Figure XII.6

Figure XII.7

Figure XII.8

Figure XII.9

Figure XII.10

Figure XII.11

Figure XII.12

Figure XII.13

Figure XII.14

Figure XII.15

Figure XII.16

Figure XII.17

Figure XII.18

Figure XII.19

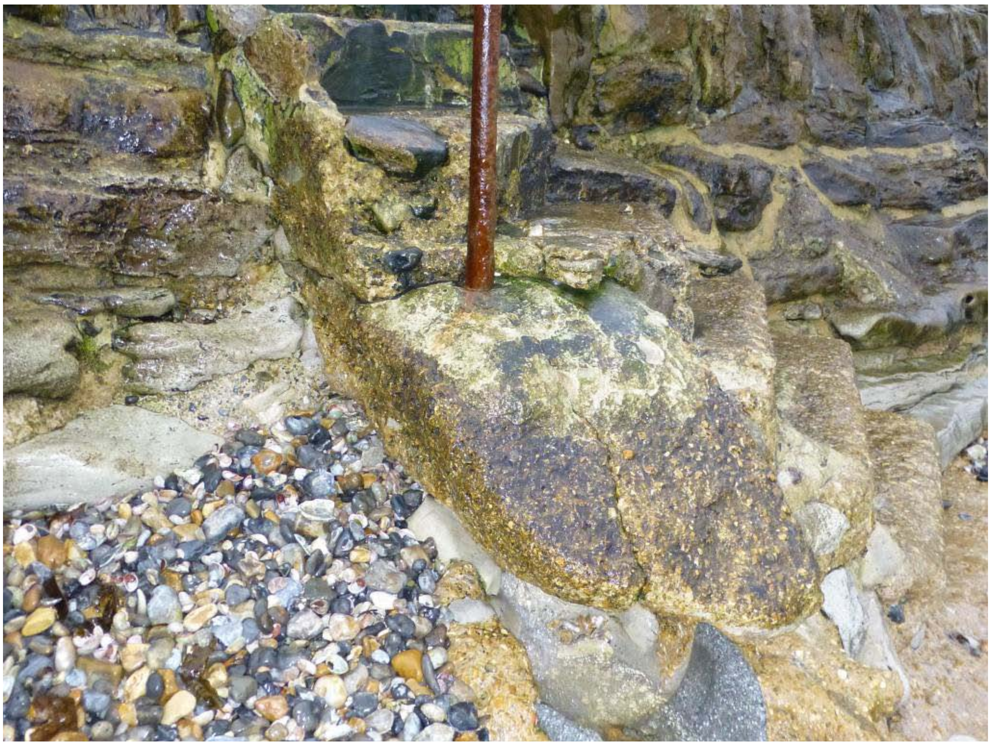


Figure XII.20

Figure XII.21

Figure XII.22

Figure XII.23

Figure XII.24

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List of Abbreviations

AONB	Area of Outstanding Natural Beauty
BMPA	Bivalve Mollusc Production Area
CD	Chart Datum
Cefas	Centre for Environment Fisheries & Aquaculture Science
CFU	Colony Forming Units
CSO	Combined Sewer Overflow
CZ	Classification Zone
Defra	Department for Environment, Food and Rural Affairs
DCWW	Dwr Cymru/Welsh Water
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
TAC	Total Allowable Catch
UV	Ultraviolet
WGS84	World Geodetic System 1984
WWTW	Waste Water Treatment Works

Glossary

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

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

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