Centre for Environment Fisheries & Aquaculture Science

www.cefas.defra.gov.uk

EC Regulation 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SANITARY SURVEY REPORT

The Fleet

November 2013

Food Standards Agency

Cover photo: Oyster trestles in the Fleet

Current Cefas sanitary survey reports and reviews are available on our website at:

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

Contacts

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

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

☎ +44 (0) 1305206600
✉ fsq@cefas.co.uk

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

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

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

Statement of use

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

Report prepared by

Alastair Cook, David Walker, Rachel Parks, Fiona Vogt, Owen Morgan.

Revision history

Version	Details	Approved by	Approval date
1	Draft for internal consultation	Alastair Cook	06/11/2013
2	Draft for client/consultee comment	Simon Kershaw	08/11/2013
3	Final pending completion of bacreriological suvrey	Simon Kershaw	24/01/2014
4	Final	Simon Kershaw	03/02/2014

Consultation

Consultee	Date of consultation	Date of response
Weymouth Port Health Authority	11/11/2013	11/11/2013
Environment Agency	11/11/2013	12/11/2013
Southern IFCA	11/11/2013	None received
Wessex Water	11/11/2013	11/11/2013
SAGB	11/11/2013	None received

Dissemination

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

Recommended Bibliographic Reference

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

Contents

1. Introduction

1.1. Legislative Requirement

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

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

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

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

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

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

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

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

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

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

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

In addition to better targeting the location of RMPs and frequency of sampling for microbiological monitoring, it is 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 Pacific oysters within The Fleet, which forms part of the Portland Harbour production area. The area was prioritised for survey in 2013-14 by a shellfish hygiene risk ranking exercise of existing classified areas. Other parts of the Portland Harbour production area were subject to sanitary surveys in 2008, 2009 and 2011.

1.2. Area description

The Fleet is the largest coastal lagoon in Britain (Jurassic Coast website, 2012) and is situated on the south coast of England, just west of Weymouth (Figure I.1). A narrow entrance connects the Fleet to the English Channel via Portland Harbour. The lagoon has an area of approximately 5 km² of which a significant proportion is uncovered at low tide. It lies behind Chesil beach, a large shingle bank 29 km in length which runs from Portland Bill to West Bay (Holt *et. al*, 2012). There are a few small streams which discharge into the Fleet but there are no major freshwater inputs.

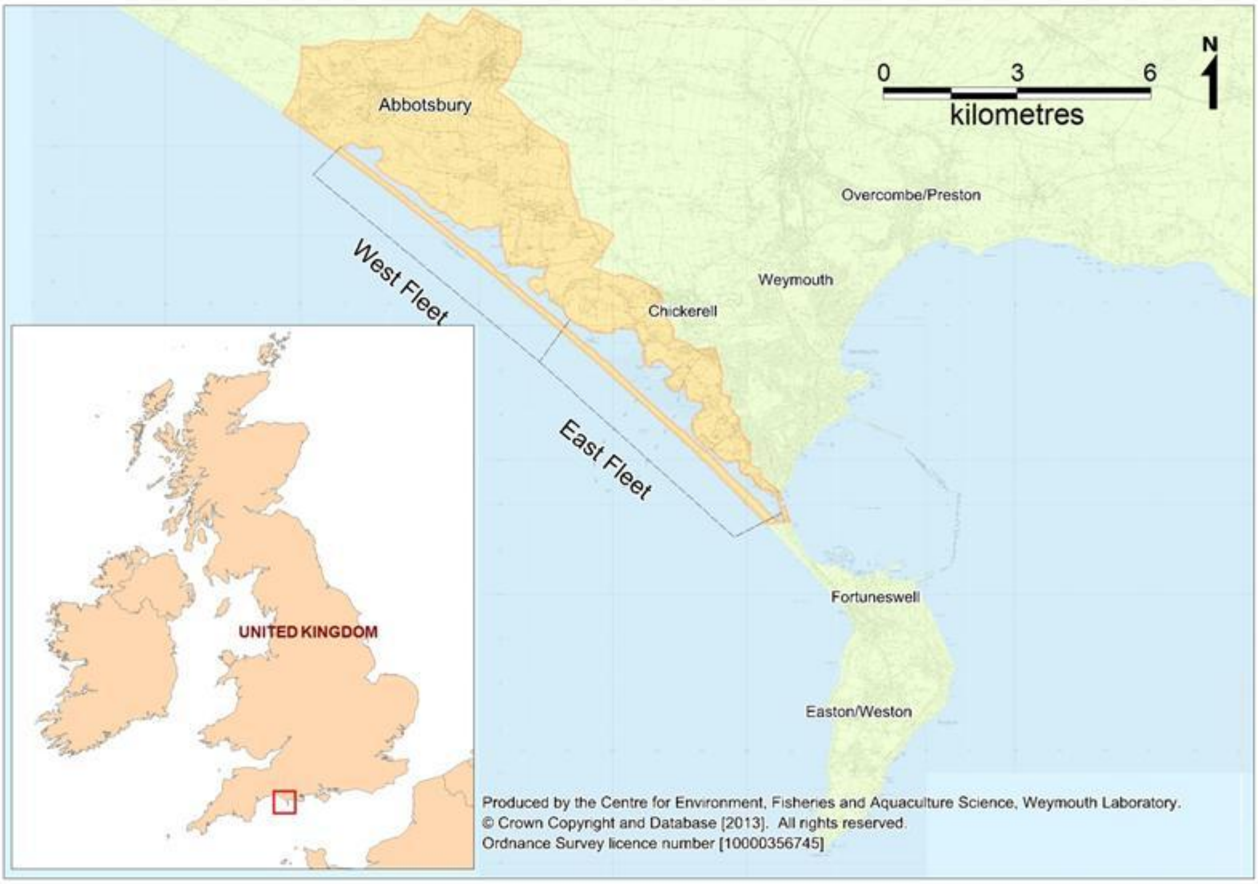


Figure I.1: Location of the Fleet

The Fleet lagoon and Chesil Beach have been recognised for their habitats and the wildlife that they attract including saltmarsh and overwintering wildfowl. Consequently, the whole of the Fleet has been designated as a Special Site of Scientific Interest (SSSI), Special Protection Area (SPA) and Special Area of Conservation (SAC). The majority has been also designated as a Ramsar site and the west Fleet forms part of an Area of Outstanding Natural Beauty (AONB).

The Fleet is connected to Portland Harbour, where there is a commercial port and a large amount of recreational boat traffic. Oysters have been harvested from the area since the 15th century and there were commercial harvesting operations in the 18th and 19th centuries (Langston *et al*, 2003). Now, only very occasional specimens of the native species remain. The oyster farm, where Pacific oysters are cultured, has been in operation for 30 years. It is under the same management as the Crab House Cafe, where most of the oysters are sold (Crabhouse Cafe website, 2013).

1.3. Catchment

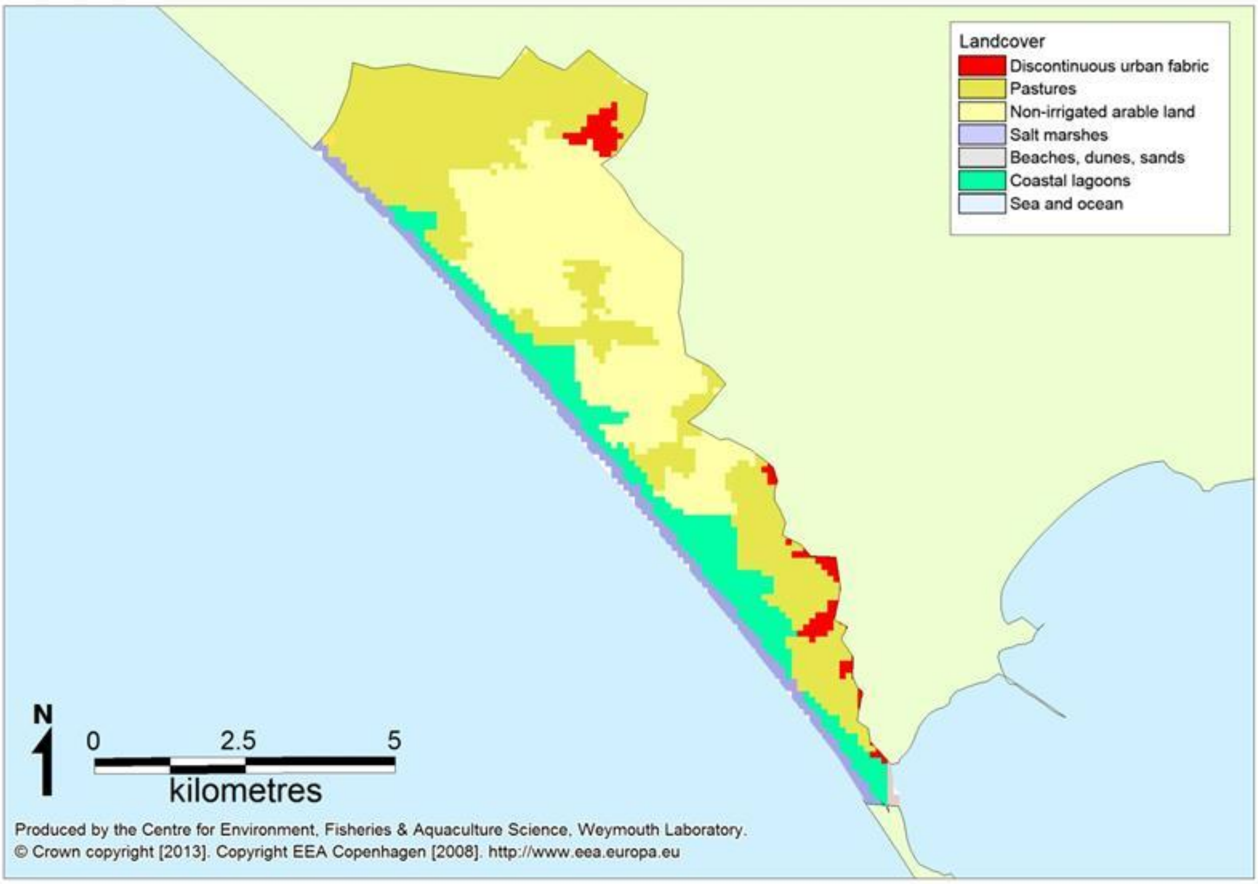


Figure 1.2: Landcover in the Fleet catchment area

Figure 1.2 illustrates landcover within the hydrological catchment of The Fleet, which covers approximately 30 km². The catchment is predominantly rural, non irrigated arable land and pasture with small clusters of urbanised land in the upper catchment. Chesil Beach is a large pebbled bank with saltmarsh which borders the seaward side of the Fleet lagoon. The outskirts of Weymouth borders the outer reaches of the Fleet, at the eastern end, where the oyster farm is located.

Different land cover types will generate differing levels of contamination in surface runoff. Highest faecal coliform contribution arises from developed areas, with intermediate contributions from the improved pastures and lower contributions from the other land types (Kay *et al*. 2008a). The contributions from all land cover types would be expected to increase significantly after marked rainfall events, particularly for improved grassland which increase up to 100 fold. The hydrogeology of the catchment ranges from very low permeability to high permeability, with the areas adjacent to the oyster farm being a mix of moderate and very low permeability (NERC, 2012). Land bordering the middle reaches of The Fleet and some parts of the upper reaches are of high permeability, so there are likely to be groundwater flows here.

2. Recommendations

2.1. Pacific oysters

Currently, there is one oyster farm in the Fleet, which consists of a main growing area and a smaller discrete pre-harvest holding area located higher up the shore. One classification zone is proposed to cover the two sites as they are located in close proximity to each other and little spatial variation in levels of contamination is anticipated across the whole site. There are very few contaminating sources in the immediate vicinity of the trestles. The Ferrybridge Pumping Station is located close to the oyster farm, but spills very infrequently so any spill event is highly unlikely to be captured during monthly monitoring. As such this discharge will not influence the location of the RMP. However, it is strongly advised that Wessex Water establish a procedure by which the harvester will be informed if the overflow is in operation in order to make decisions regarding management of the fishery. The few sources of contamination within the Fleet discharge up from the oyster farm, to an enclosed and shallow environment with little dilution. Sources of contamination to the Fleet include agricultural runoff and two small sewage works which will be carried into the lagoon via several minor watercourses. In the wider context, the few and minor sources within Portland Harbour receive a high degree of dilution and as such are unlikely to cause significant impact at the oyster farm. Historical microbiological monitoring supports this assertion in that sample results increase from the eastern side of Portland Harbour towards the west of the harbour and into the Fleet. However, the limited results of a bacteriological survey undertaken during the winter indicate that across the oyster farm at least, the opposite was the case at the time of survey. This may possibly be attributable to the presence of overwintering waterbirds, or to runoff from areas of hard standing in the Ferrybridge area. Whilst this may not necessarily apply throughout the year, it is recommended that the RMP be located at the loading bay, contrary to initial recommendations in the draft report. Sampling should be on a monthly basis for a full year round classification. Samples should be of Pacific oysters of a harvestable size. The RMP tolerance should be 10 m for handpicked samples.

3. Sampling Plan

3.1. General Information

Location Reference

Production Area	Portland Harbour (Fleet only)
Cefas Main Site Reference	M025
Ordnance survey 1:25,000 map	OL15
Admiralty Chart	2255

Shellfishery

Species/culture	Pacific oyster	Trestle culture
Seasonality of harvest	Year round	

Local Enforcement Authority

Name	Weymouth Port Health Authority Council Offices North Quay WEYMOUTH Dorset DT4 8TA
Environmental Health Officer	Nigel Emery
Telephone number ☎	01305 838432
Fax number	01305 766684
E-mail	envhealth@weymouth.gov.uk

3.2. Requirement for Review

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

Classification zone	RMP	RMP name	NGR	Latitude & Longitude (WGS84)	Species	Growing method	Harvesting technique	Sampling method	Tolerance	Frequency	Comments
Fleet Oyster Farm	B25AI	Fleet Oysters	SY 6647 7627	50° 35.112 N 2° 28.499 W	Pacific oyster	Trestle	Hand	Hand	10m	Monthly	Replaces current RMP.

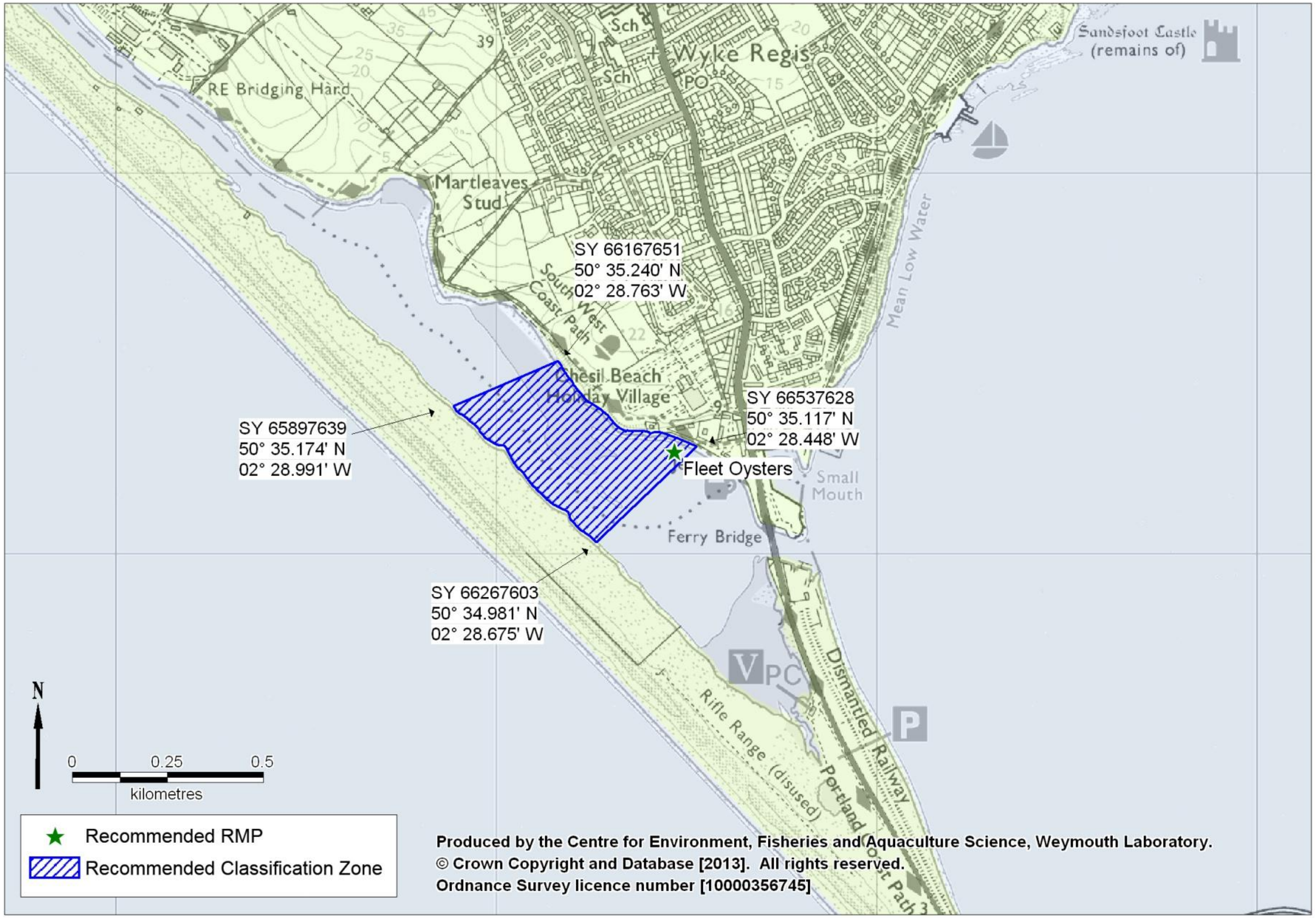


Figure 3.1: Recommended zoning and monitoring arrangements (Pacific oysters)

4. Shellfisheries

4.1. Species, location and extent

The Fleet supports a Pacific oyster trestle farm, the extent of which is shown in Figure 4.1.

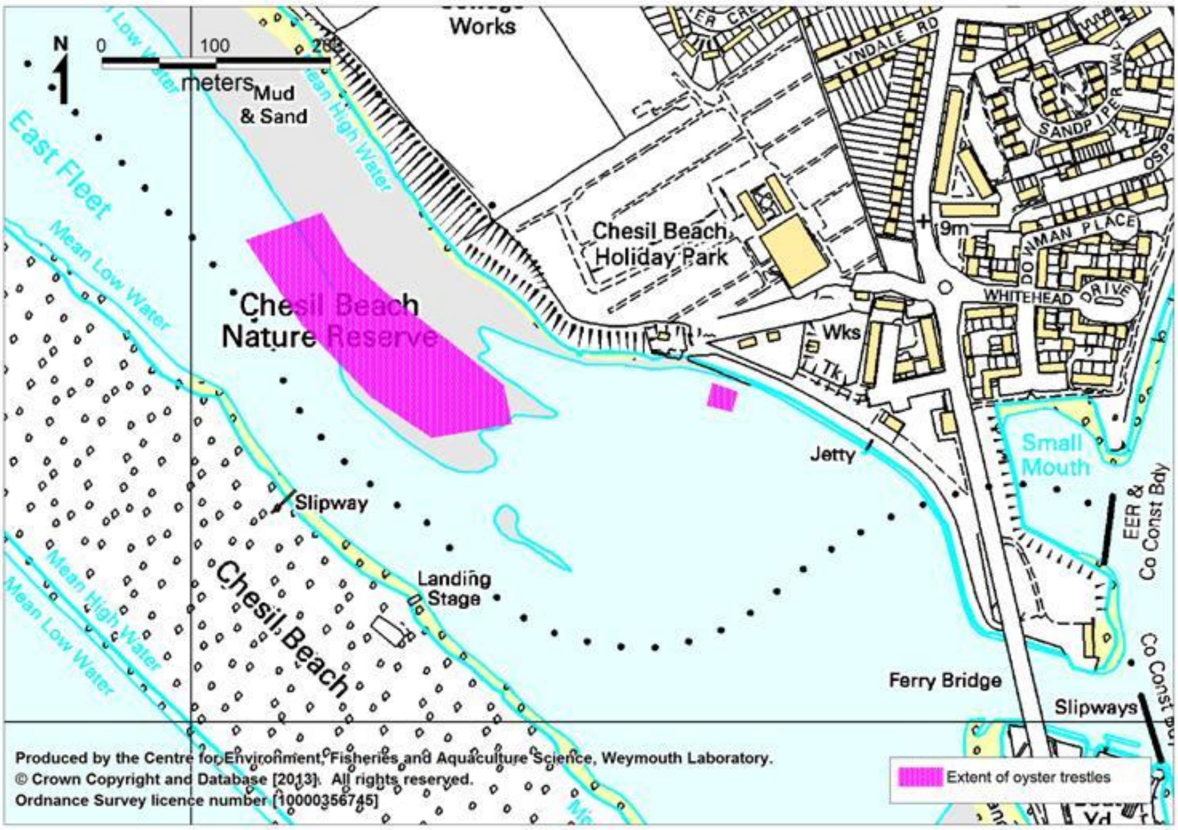


Figure 4.1: Extent of trestle farm

The farm consists of a large block of trestles at a lower elevation where most of the stock is held, and a smaller and more accessible pre harvest holding area. There are also some wild shellfish in the Fleet, including clams and cockles. An application to harvest Manila clams and native clams within the outer reaches of the Fleet was received in 2011. However, it transpired that there were insufficient stocks to even provide regular samples, so these plans were abandoned and it can be concluded that there are insufficient stocks to merit classification of the area for these species. The manager of the oyster farm indicated he had no interest in harvesting any of the naturally occurring shellfish stocks in the area, although some limited casual gathering does occur from time to time.

4.2. Growing Methods and Harvesting Techniques

Pacific oysters are grown from seed on trestles, taking between two and three years to reach maturity. Harvesting is by hand, and there are purification tanks on site.

4.3. Seasonality of Harvest, Conservation Controls and Development Potential

No conservation controls apply to cultured Pacific oysters. Harvest may be at any time of the year, although the on-site restaurant to which most of the oysters are supplied closes for a couple of months in the winter. The site manager indicated no intention to expand the operation, which has been running steadily at around its current capacity for many years.

4.4. Hygiene Classification

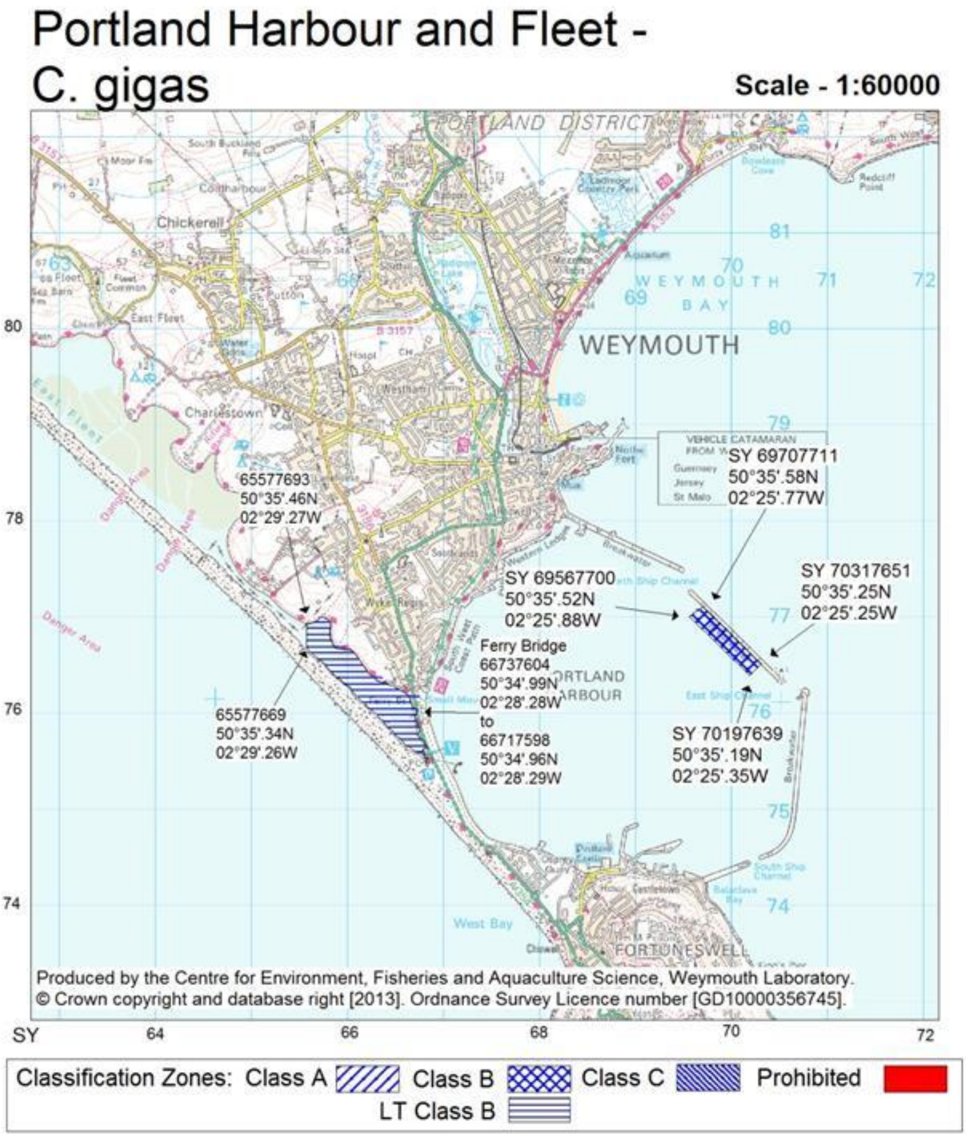
Table 4.1 lists all classifications within The Fleet from 2004 onwards. It falls within the Portland Harbour production area, which currently includes several classified areas within the harbour, and has historically also included Weymouth Bay and the Shambles Bank.

Table 4.1: Classification history for The Fleet, 2004 onwards

Area	Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Fleet – F1	Pacific oyster	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT

LT denotes long term classification

The Fleet has held a steady B classification for the last decade.



Classification of Bivalve Mollusc Production Areas: Effective from 1 September 2013

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 Mytilus spp. and Tapes spp. at Portland Harbour and Fleet

Food Authority: Weymouth Port Health Authority

Figure 4.2: Current Pacific oyster classification map

Table 4.2: Criteria for classification of bivalve mollusc production areas.

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

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

5. Overall Assessment

5.1. Aim

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

5.2. Shellfisheries

The Fleet supports a long established Pacific oyster farm which covers an area of about 18,000 m^2. Oysters are grown from seed stocks to a market size on trestles, a process which takes two to three years. The majority produced are supplied to a neighbouring restaurant, which is under the same management. There is a small pre harvest holding area nearer to the shore and from there oysters are taken to the purification facilities on site. Whilst there is a seasonal lull in harvesting for a couple of months in winter, when the restaurant closes, harvesting may occur at any time of the year so continued year round classification is required. There are no plans to extend the farm so only the existing footprint requires classification.

Whilst there are naturally occurring stocks of other bivalve species, such as native clams and cockles, none are thought to be present at commercially exploitable densities. Some casual gathering of these does occur from time to time.

5.3. Pollution Sources

Freshwater Inputs

The Fleet has a relatively small catchment of about 28km^2 in total. The catchment is predominantly rural, non irrigated arable land and pasture with small areas of urbanised land in the upper catchment. The hydrogeology varies from very low permeability to high permeability, with the areas adjacent to the oyster farm being a mix of moderate and very low permeability. Land bordering the middle reaches of The Fleet and some parts of the upper reaches are of high permeability, so there are likely to be groundwater flows here.

Due to the small catchment size, there are no major freshwater inputs to the Fleet. A series of seven minor watercourses drain to the Fleet at various points, and all enter the lagoon to the west of The Narrows. A few spot discharge estimates were available for each of these seven streams. Mean discharge rates ranged from 0.001 to 0.047m^3/sec, so none carry large volumes of runoff. They will carry some contamination from land runoff and so are likely to contribute to the concentrations of faecal indicator bacteria in the area. However, as they are all small and some distance from the fishery, it is anticipated that their impacts will generally be minor, and may not extend as far as the oyster farm in most cases.

Mean flow rates are relatively low within the smaller watercourses, however the data available is not fully representative as the sampling is sporadic and the number of recordings taken is low. Therefore, comparisons between monthly flow rates cannot be made.

Seasonal variation of rainfall is relatively limited but the highest rainfall on average was during the colder months and this tends to result in increased flow rates during and after heavy rainfall events. However, the seasonal pattern of flows will not be 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. Two streams discharging to the middle reaches of The Fleet are winterbournes and dry out over the summer, for a period of about 3-4 months.

During the shoreline survey, which was conducted under wet weather conditions, watercourses which could be safely accessed were sampled for *E. coli* and spot flow measurements were made. The results for the water samples taken from the streams discharging north west of the oyster farm contained relatively high levels of *E. coli* (9000 cfu/100ml). However, the low discharge volume meant that the bacterial loading that this stream was delivering was only about 3.8 x 10^9 *E. coli*/day.

Human Population

The total resident population within the Fleet catchment area was approximately 13,000 at the time of the last census. Around 88% of the catchment area has a population density of less than 100 people/km^2, with population densities highest in the south at Wyke Regis, which is directly adjacent to the Fleet oyster farm. There are five holiday or caravan parks along the Fleet which will have a higher number of residents during the warmer months, potentially increasing the amount of sewage discharged by sewage works serving this area. However, the main sewage treatment works discharges 1.2 km offshore, to the south west of Chesil Beach.

Sewage Discharges

There are two water company sewage works (Abbotsbury and Langton Herring) which discharge indirectly to the Fleet via streams. They are both treated by biological filtration, and are relatively small, generating estimated bacterial loadings of $9.9x10^{11}$ and $1.3x10^{10}$ faecal coliforms per day respectively. They are located approximately 12 and 8.5 km west of the oyster farm and so are likely to have limited, if any, impacts on the shellfishery. There are also a number of private discharges in the area, some of which discharge to watercourses and some to soakaway and groundwater. Those that discharge to water are generally treated by biological filtration, usually via a package treatment plant. The majority of these are small, serving one or two properties but for those that are larger, whilst they will contribute to the levels of contamination carried into the area by these watercourses they are located at sufficient distance from the shellfishery to be of minor significance at most.

As well as continuous sewage discharges, there are a few intermittent overflows associated with the water company sewerage networks. Three of these discharge to watercourses draining to the upper reaches of the Fleet. None of these three has spill monitoring equipment so it is difficult to assess their potential for impacting on the oyster farm, although all are a significant distance from it. There is also one intermittent discharge immediately adjacent to the oyster farm (Ferrybridge PS) and four further intermittent discharges to neighbouring Portland Harbour. Spill records from these indicate that the four discharges to Portland Harbour hardly spilled at all, spilling for <0.1% of the time in recent years. This, together with their distance from the oyster farm, suggests they will be of no impact. The Ferrybridge PS spilled even less, only recording three spill events totalling just under 10 minutes during the last two reporting years. Significant discharge from this pumping station are therefore likely to be an extremely rare event, and the chances of capturing the impacts of such a spill under monthly monitoring used for classification are vanishingly small. However, if a significant problem did arise, such as a blockage or pump failure, highly contaminated oysters may potentially be harvested under a B classification if the site manager was not aware of the situation. The only way that such a situation may be avoided is if the water company establishes a means for rapidly informing the oyster farm in the event of a significant spill.

In summary there is little in the way of sewage inputs to the area, and most of these are minor and a significant distance from the oyster farm. There may be slightly higher levels of sewage related contamination towards the inner reaches of the Fleet as there are several small continuous sewage inputs to watercourses draining to this enclosed water body. Of possible concern is the Ferrybridge PS intermittent discharge, which is immediately adjacent to the oyster farm, although event monitoring records indicate that this hardly ever spills.

Agriculture

The majority of land within the Fleet catchment is agricultural. It is a mix of pasture and arable land, with mainly pasture in the vicinity of the oyster farm. A total of 1,454 cattle were recorded within the catchment area in the 2010 agricultural census, so some impacts from grazing animals are anticipated. The extent of their impacts on the oyster farm will depend largely on location of grazing, and the degree to which they are able to access watercourses draining to the Fleet. During the shoreline survey only two horses were observed on fields behind Martleaves Bay, although the local topography may have obscured some areas. The empty fields between the Chesil Holiday Park and the Bridging Camp are likely to be used for grazing livestock on at times.

The primary mechanism for mobilisation of faecal matter from agricultural land is via land runoff, so fluxes of livestock related contamination into the estuary will be highly rainfall dependent and will arrive via watercourses draining farmlands. There is likely to be some seasonality in levels of contamination originating from livestock. Rainfall and river flows are generally higher during the winter months, although high rainfall events may occur at any time of the year. Peak concentrations of contamination from cattle entering watercourses are likely to arise when heavy rain follows a significant dry period (the 'first flush'). Numbers of cattle will increase significantly in the spring, with the birth of calves, and decrease in the autumn when animals are sent to market. The seasonal pattern in application of manures and slurries to agricultural land is uncertain. Cattle may be housed indoors during the winter, so applications of slurry collected from such operations is likely to be spread in the late winter and spring, depending on the storage capacities of each farm.

Boats

The discharge of sewage from boats is a potential source of bacterial contamination of shellfisheries within the Fleet. Although boat traffic within the Fleet lagoon is relatively low, there is significant boat traffic in Portland Harbour to which the Fleet is connected. Portland Harbour is a busy port with around 300 commercial ships and around eleven cruise ships docking each year. Merchant shipping vessels are not permitted to make overboard discharges to inshore waters so vessels associated with the commercial port should be of no impact. There is a large commercial fishing fleet (around 84) in Weymouth and Portland, with the majority operating out of Weymouth. However, fishing from boats is prohibited in the Fleet due to its designation as a bass nursery area.

There is a marina within Portland harbour with 560 annual berths and alongside berths for several super yachts. There are some moorings for smaller craft in the east Fleet and seasonal moorings for yachts off Castle Cove and Osprey Quay. None of the boats seen moored in the Fleet appeared sufficiently large to have on board toilets. Sewage pump out facilities are available in Portland Harbour and a byelaw prohibits the discharge of any matter into the harbour. However, it is possible that private vessels such as yachts, motor cruisers and fishing vessels of a sufficient size may still make overboard discharges from time to time. This may be most likely to occur when the boats are moored or at anchor, particularly if they are in overnight occupation. The areas that are at highest risk from microbiological pollution therefore include Castle Cove and Osprey Quay. Peak pleasure craft activity is anticipated during the summer, so associated impacts are likely to follow this seasonal pattern. It is difficult to be more specific about the potential impacts from boats and how they may affect the sampling plan without any firm information about the locations, timings and volumes of such discharges.

Wildlife

The Fleet features a variety of habitats including a large shingle bank, saltmarsh, eelgrass beds and intertidal flats and these attract significant populations of wildlife. The most significant wildlife aggregation in terms of shellfish hygiene is likely to be overwintering waterbirds (waders and wildfowl). The Fleet and Portland Harbour support large numbers of the internationally important species, with an average total count of 15,873 waterbirds was reported over five winters up to 2010/11 for the Fleet and Wey. Waders, such as dunlin and oystercatchers forage upon invertebrates on intertidal areas, including the area occupied by the oyster farm, and so are likely to contribute to the *E. coli* counts found within the oysters. Other species such as grazing wildfowl will also contribute via direct deposition on saltmarsh and eel grass beds, and runoff from adjacent pastures. Such areas are more geographically separate from the oyster farm, so grazing birds will not deposit contamination in the immediate vicinity of the farm in the way that wading birds will.

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. Bird numbers and potential impacts on the fisheries are therefore much lower during the summer. In 2000, a total of 95 pairs of Little Tern, Herring gulls and Great Black-backed Gull were recorded within the Fleet and the surrounding areas. 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. At certain states of the tide they will rest on the trestles, and so may defecate directly onto the oyster bags.

The oldest managed population of about 850 Mute swans is located in the upper reaches of the Fleet, in Abbotsbury where they are provided with safe nesting enclosures and fed daily. They are present all year round, although they may be more dispersed outside of the spring/summer breeding season. They will contribute to the levels of faecal indicator bacteria in the Fleet, although whether they are of any significance to the oyster farm is uncertain, given the distance between the two.

Impacts from birds, whilst they may contribute significantly to *E. coli* counts observed in oysters, particularly during the winter months are of a diffuse nature. As such, it is not possible to select specific RMP locations to best capture these impacts so they will have no material bearing on the sampling plan. No other wildlife species which may have a bearing on the sampling plan have been identified.

Domestic animals

Dog walking takes place on beaches/intertidal areas and paths adjacent to the shoreline of the survey area and could represent a potential source of diffuse contamination to the near shore zone. Dog walkers are commonly observed along the shore between Ferrybridge and The Narrows. 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												
Urban runoff												
Continuous sewage discharges												
Intermittent sewage discharges												
Birds												
Boats												

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

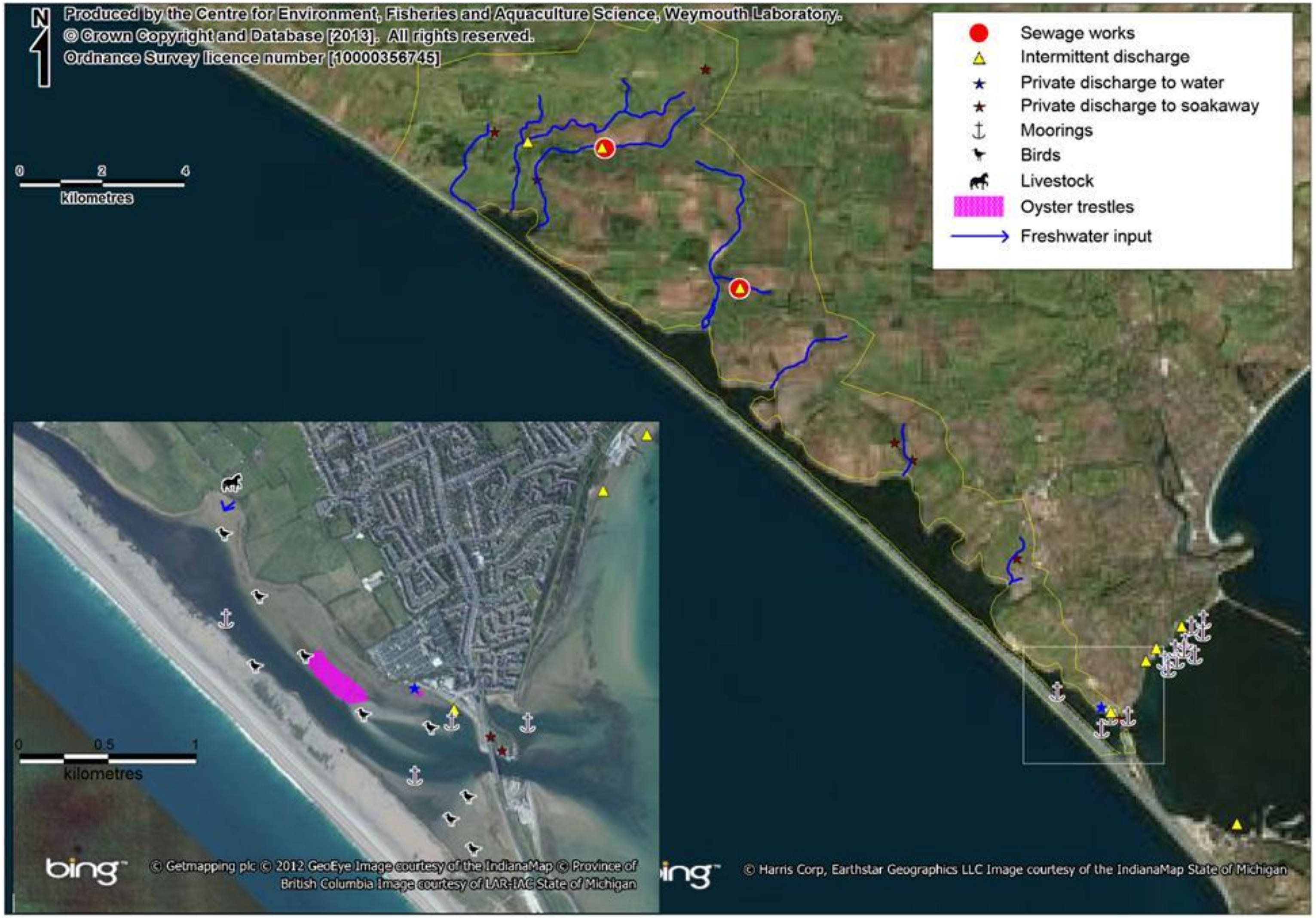


Figure 5.1: Summary of main contaminating influences
Bing, 2010

5.4. Hydrography

The Fleet is a large saline lagoon located between the Chesil Bank and the Dorset coast. It is about 12km long, and covers an area of about 5km^2, a large proportion of which is intertidal. It is connected to the English Channel via a single entrance to Portland Harbour at its eastern end. It receives only minor freshwater inputs from a small catchment area. The oyster farm is located at the eastern end, just inside its entrance. There are significant constrictions either side of it, at Ferrybridge and The Narrows, where scouring occurs from strong tidal currents. These strong tidal flows will promote turbulent mixing, so contamination arriving from both Portland Harbour and further up the lagoon will be well mixed in the water column. There is a subtidal channel between Ferrybridge and Narrows which runs along the base of Chesil Beach. The majority of intertidal areas are to the north of this channel, including the area upon which the oyster farm is located. Portland Harbour is a large and deep water body, so offers a considerably higher dilution potential than the relatively narrow, enclosed and shallow Fleet lagoon.

The Fleet has a small tidal range, not exceeding 2m at Ferrybridge on spring tides. Despite this, strong tidal streams are encountered in the survey area, particularly at Ferrybridge and The Narrows. Currents in the immediate vicinity of the oyster farm are slower, in the order of 0.5m/s. Tidal streams are bidirectional, flooding up the Fleet from Portland Harbour, with the reverse occurring on the ebb. As such, the oyster farm may be subject to contamination originating both in Portland Harbour and from further up the Fleet. There is a double low water, which results in a 3-4 hour stand at this time.

A modelling study indicated that particles released from Ferrybridge on a flood tide reached The Narrows within an hour. Particles released at Castle Cove in Portland Harbour were carried into the Fleet after one tidal cycle. Particles released from Osprey Quay did not reach The Fleet until three tidal cycles had passed, and particles released at the Portland Port area were flushed out into the English Channel. Therefore, sources discharging to the north shore of Portland Harbour may be of some delayed influence (three intermittent discharges and a large area of yacht moorings). Sources discharging at Osprey Quay and Portland Port (boats and one intermittent discharge) are unlikely to impact.

West of the Narrows, tidal range decreases progressively, as will current speeds and the amount of tidal flushing. It is likely that contamination released from the upper reaches of the lagoon will take a considerable time to reach the narrows, and as such significant bacterial dieoff is anticipated. Tidal flushing times from the Abbotsbury area have been estimated at between 10-40 days. However, its enclosed and shallow nature will provide little scope for dilution. Therefore, water carried on the ebb tide from the upper reaches of the lagoon may carry higher levels of contamination than that originating from Portland Harbour.

Superimposed on tidal currents are the effects of freshwater and wind. Freshwater inputs to the Fleet and Portland Harbour are minor, and in the outer Fleet where the oyster farm is located salinities are that of full strength seawater. Together with the high potential for mixing at The Narrows and Ferrybridge, density driven currents are unlikely to be of any significance in the vicinity of the farm. The shallow enclosed and poorly flushed nature of the Fleet results in a noticeable decrease in average salinity in its upper reaches. It is quite possible that some density driven circulation arises here, whereby there will be a net seaward flow of less dense freshwater at the surface, and a return of more saline water at depth. This may accelerate the passage of freshwater borne contamination out of the Fleet to some extent. The observed salinity gradient also suggests an underlying gradient of increasing runoff borne contamination towards the upper reaches. However, no correlation between salinity and levels of faecal coliforms was observed at The Narrows. Whether this is due to the small numbers of samples considered, and the low variation in salinity and faecal coliforms, or the dieoff of bacterial indicators during passage is uncertain. Either way, the salinity gradient between The Narrows (mean salinity 33.7) and Ferrybridge (mean salinity 34.3) is very slight, so would be barely noticeable across the oyster farm.

Strong winds will drive surface currents, which will create return currents either at depth or along sheltered margins. The Fleet will be most affected by winds from the southeast and north west, which will blow along its length. Wind driven currents may be of particular significance in the upper reaches of the Fleet, and in Portland Harbour, where tidal currents are slow. North westerly winds would promote the advection of any surface entrained contamination towards the oyster farm. Exact effects are dependent on the wind speed and direction as well as state of the tide and other environmental variables so a great number of scenarios may arise. Where strong winds blow across a sufficient distance of water they may create wave action, and where these waves break contamination held in intertidal sediments may be resuspended, although given the enclosed nature of the Fleet this will only occur when the winds are blowing along it.

5.5. Summary of Existing Microbiological Data

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

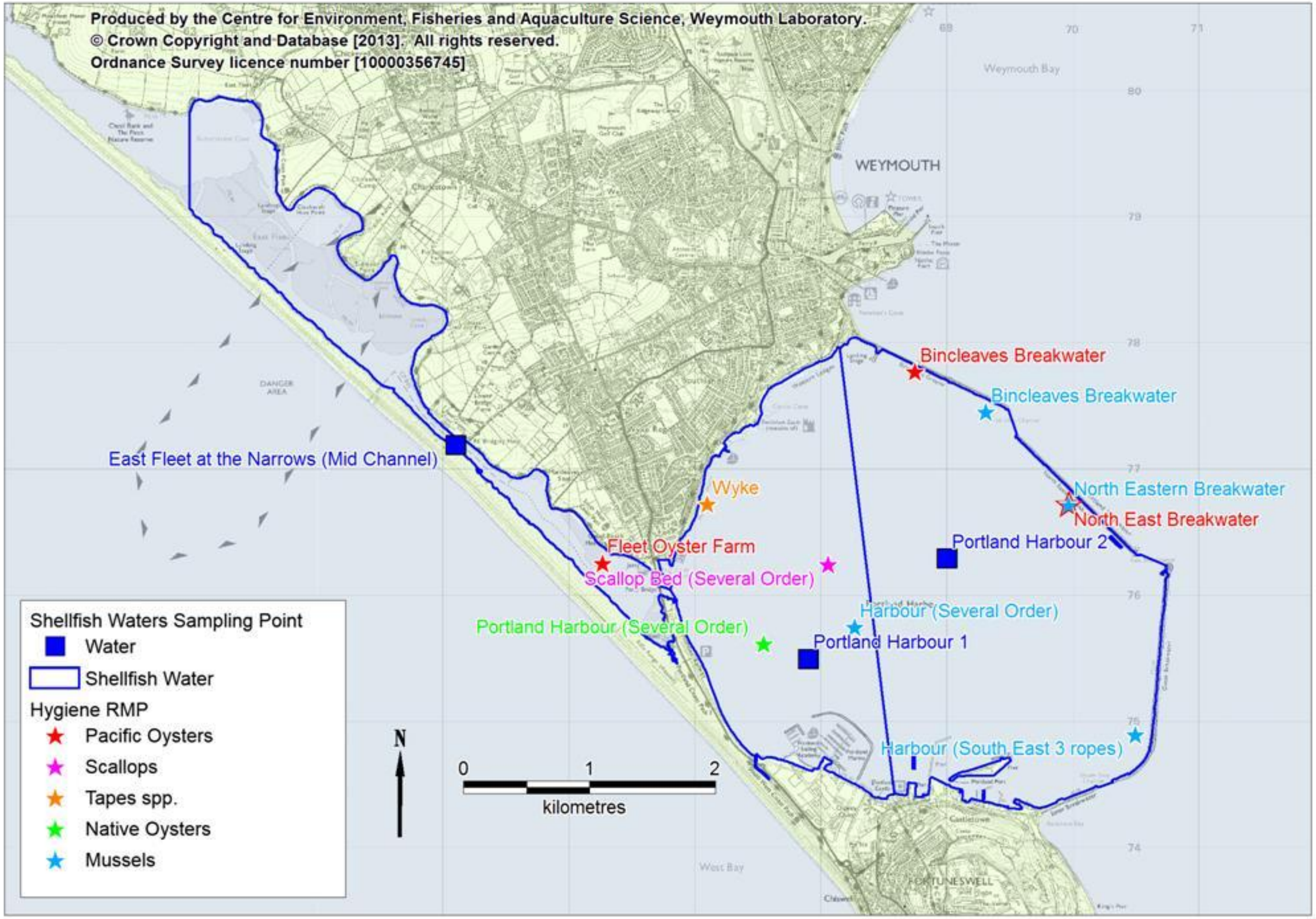


Figure 5.2: Microbiological sampling sites

Shellfish waters

Under the shellfish waters monitoring programme three sites in the Fleet and Portland Harbour (Portland Harbour East, Portland Harbour West and The Fleet) were sampled for faecal coliforms in water on a quarterly basis. The Portland Harbour West shellfish water has had two monitoring points in the past, but now only has one (Portland Harbour 1 New). Portland Harbour 1 Old had very few samples taken and therefore could not be subject to any statistical analysis. Average faecal coliforms results were low and were broadly similar, with geometric means of 3.6, 2.4 and 2.7 faecal coliforms/100ml for The Narrows in the Fleet, Portland Harbour 1 New in Portland Harbour West and Portland Harbour 2 in Portland Harbour East, respectively. Statistical comparisons showed that there were no significant differences in faecal coliforms between the sites. Correlated paired same day samples suggest that Portland Harbour 1 New (West) and Portland Harbour 2 (East) are subject to similar sources of contamination, which is unsurprising given their proximity. There were insufficient paired results for comparison between The Narrows and the Portland Harbour sites to be made. Faecal coliform levels at all three sites have increased since 2008, although faecal coliform levels at the Portland Harbour sites did not start to increase until 2011. Seasonal variation was only found at The Narrows, in the Fleet, where faecal coliform levels were significantly higher in the autumn than in any of the other seasons which suggests that there are seasonal influences here. There were not enough data to analyse tidal effects. The effects of rainfall on levels of contamination at the water quality monitoring sites were investigated and it was seen that rainfall had a rapid but short lived affect on faecal coliform levels at the Narrows. At the Portland Harbour sites, rainfall took longer to influence faecal coliform levels, but the effect was longer lived than in the Fleet. The effect of salinity on faecal coliforms at shellfish waters sites was investigated but no significant correlations between were found. There is variation in salinity in the Fleet but perhaps surprisingly there is no correlation with results here.

Shellfish Hygiene classification monitoring

Under the shellfish hygiene classification monitoring programme there are a total of 10 RMPs in the Fleet and Portland Harbour that have been sampled between 2003 and 2013. Only one of these RMPs (Fleet Oyster Farm) is located in the Fleet. The Harbour (Several Order) mussel, Portland Harbour (Several Order) native oyster and the Wyke Tapes spp. RMPs were all sampled on fewer than ten occasions and will not be considered further. Statistical comparisons of mussel RMPs showed that there were no significant differences in results between sites whereas comparisons for Pacific oyster RMPs revealed significant differences with *E. coli* results at Fleet

Oyster Farm significantly higher than at the other RMPs in Portland Harbour, and North East Breakwater had higher results than Bincleaves Breakwater.

At the mussel RMPs where sampling occurred for a sustained period, whilst there was slight variation in results, *E. coli* levels remained broadly stable over time.

Oyster sampling revealed that *E. coli* levels at the Fleet Oyster Farm RMP have remained stable from 2003 to present. At Bincleaves Breakwater, *E. coli* levels increased slightly from the start of sampling in 2007 until the cessation of sampling in 2011. At North East Breakwater *E. coli* levels appear to have increased dramatically since the initiation of sampling in 2011, however, it is likely that this trend is skewed by the initial very low results and a single high result in July 2012. It is therefore not possible to say with any degree of certainty whether there has been a trend of increasing *E. coli* levels.

At the Scallop Bed RMP, *E. coli* levels have remained relatively stable since 2003, with a slight decrease in 2006.

Seasonal trends were investigated and it was found that there were no significant differences in *E. coli* levels between seasons at Bincleaves Breakwater or North Eastern Breakwater mussel RMPs. However there was a significant difference between seasons at Harbour (South East 3 ropes) with *E. coli* levels significantly higher in spring than in summer. No significant differences between seasons were found at any of the Pacific Oyster RMPs, including Fleet Oyster Farm. A significant difference between seasons was found at the Scallop Bed RMP with levels of *E. coli* higher in spring than in summer.

There was a significant correlation with the spring/ neap tidal cycle for mussels at North Eastern Breakwater and Harbour (South East 3 Ropes) where mussel results were significantly correlated with both the high/ low and spring/neap tidal cycles. Slightly higher *E. coli* levels tended to occur during the ebb tide at the Harbour (South East 3 ropes) mussel RMP suggesting that more contaminated water moves out from the harbour on the ebb. At north Eastern Breakwater, slightly higher *E. coli* levels tended to occur a few days before the neap tide, whereas at Harbour (South East 3 ropes), slightly higher results tended to occur as the tide increases from neaps to springs.

At the oyster RMPs, both Fleet Oyster Farm and Bincleaves Breakwater results were significantly correlated with the spring/neap tidal cycle. At Fleet Oyster Farm, fewer low results occurred on spring tides perhaps due to an increased flux of more contaminated water from the upper Fleet. Whilst Bincleaves Breakwater results did correlate with the spring/neap tidal cycle no strong pattern became apparent when the data was plotted. No significance was found with tidal cycles for any other sites.

The effects of rainfall on levels of contamination were investigated and it was found that rainfall rapidly had a significant impact on *E. coli* levels in both mussels and oysters at North Eastern Breakwater. The reasons for this are unclear, given its location in open deep water. However at all other sites, including at Fleet Oyster Farm, it took at least two days until rainfall impacted *E. coli* levels. However, the impact of rainfall at the oyster farm quickly subsided, suggesting localised rainfall dependent impacts are of significance.

Overall, when considering flesh results from both Shellfish Waters and shellfish hygiene monitoring, the spatial trend of contamination generally appears to be highest in the Fleet, and the western part of Portland Harbour, decreasing towards the easterly breakwaters of the harbour. This suggests that most sources of contamination are located in the west of Portland Harbour, and within the Fleet itself.

Bacteriological survey

The results of a limited bacteriological survey conducted during the winter, consisting of three samplings of Pacific oysters from three locations across the farm showed that results were consistently higher towards the eastern end. Whether this is the case throughout the year is uncertain, but the survey results suggest that the RMP should be located at the holding area at the eastern end of the farm.

Appendices

Appendix I. Human Population

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

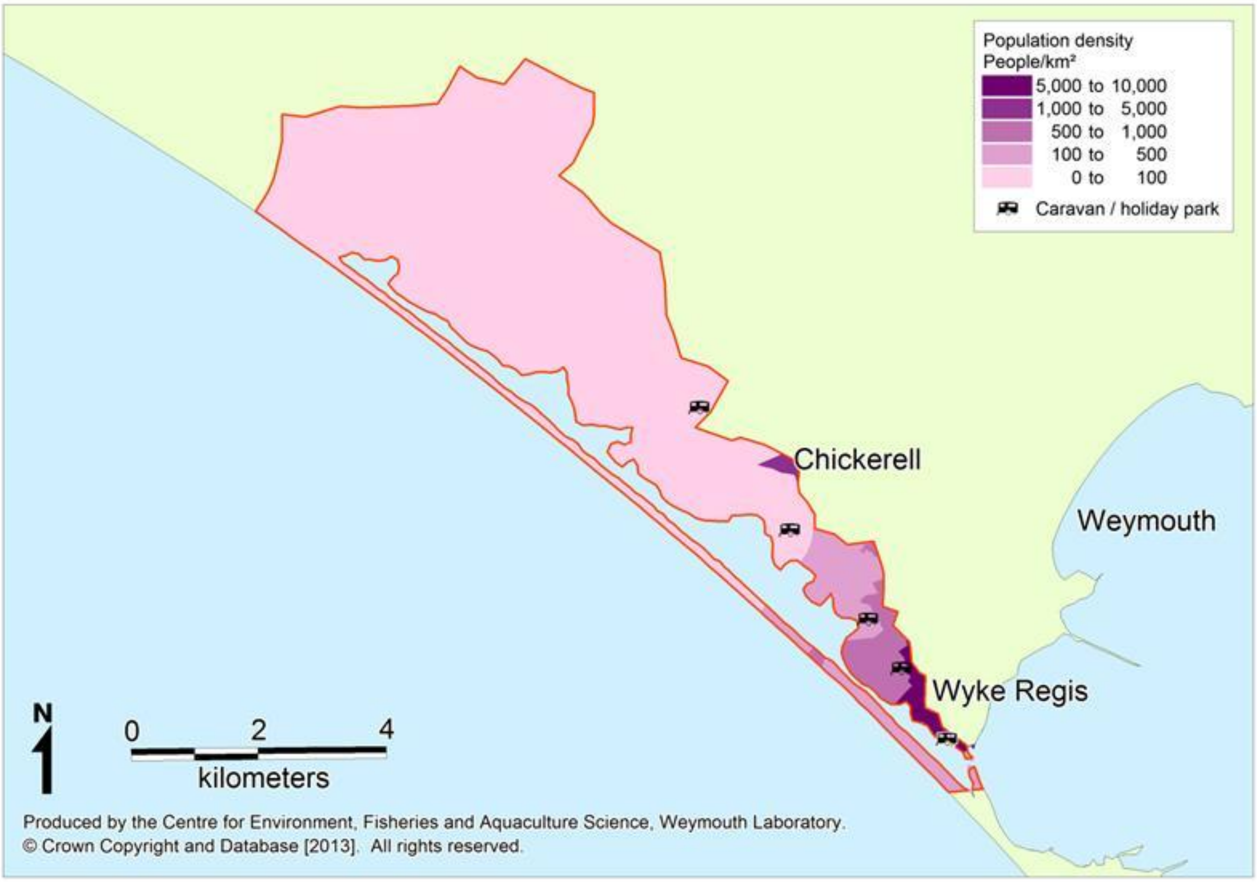


Figure I.1: Human population density in census areas in the Portsmouth Harbour catchment.

Total resident population within the Fleet catchment area was approximately 13,000 at the time of the last census. Figure I.1 indicates that around 88% of the catchment area has a population density of less than 100 people/km² and that population densities are highest in the south, around Wyke Regis which is directly adjacent to the Fleet Oyster Farm.

There are five holiday or caravan parks along the Fleet. The residence of these sites will increase during the warmer months, potentially increasing the amount of sewage discharged by sewage works serving this area.

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

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

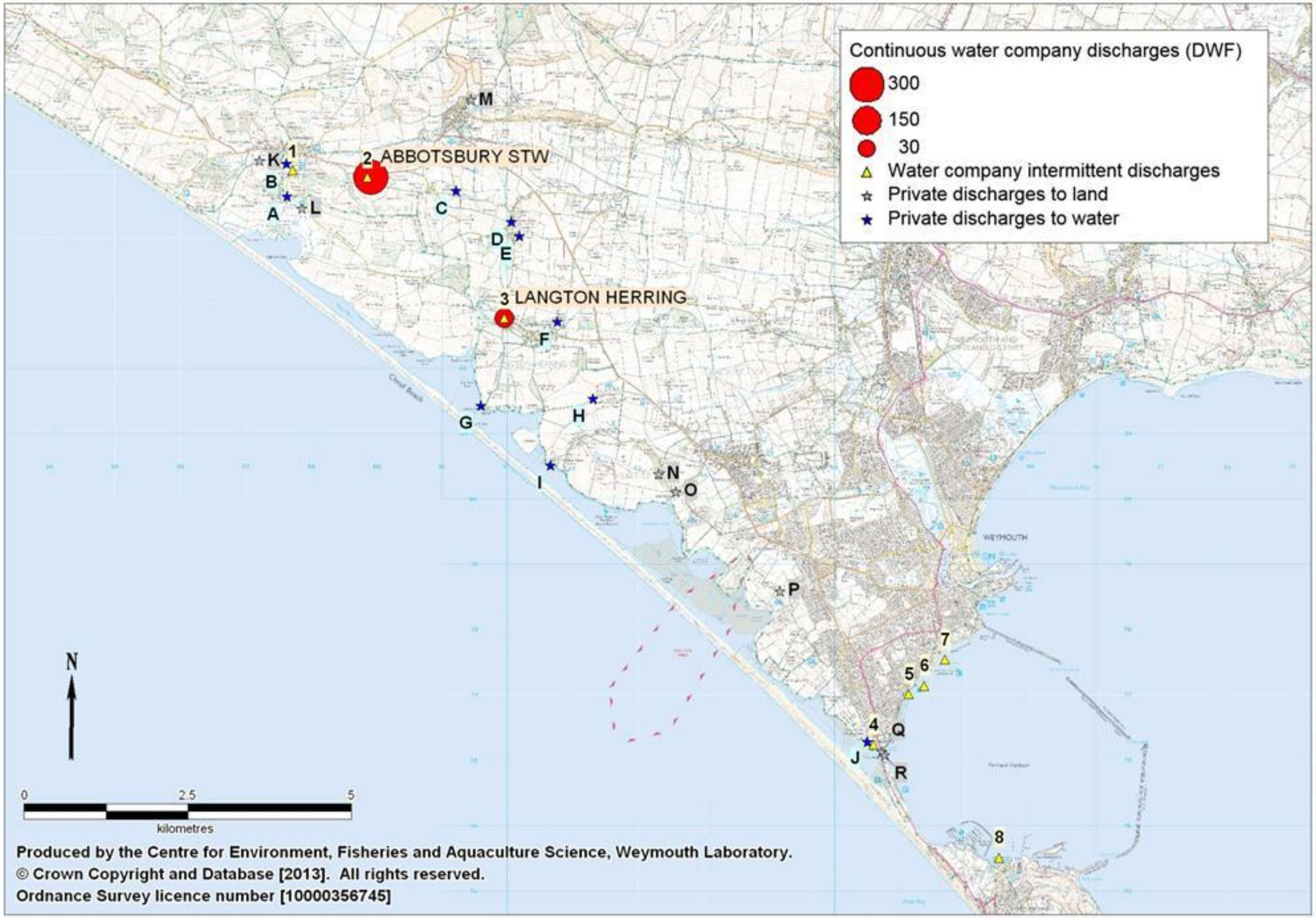


Figure II.1: Sewage discharges to the Fleet catchment

Sewage from Weymouth and Portland is treated at a large sewage works in Wyke Regis, and discharged via long sea outfall 1.2 km off Chesil Beach. This discharge will therefore have no impact on water quality within the Fleet. There are two continuous water company discharges to the area, details of which are presented in Table II.1.

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

Name	**NGR**	**Treatment**	**Dry weather flow (m^3/day)**	**Estimated bacterial loading (cfu/day)**	**Receiving environment**
Abbotsbury STW	SY5890684921	Secondary	300	$9.9x10^{11}$*	Abbotsbury Brook
Langton Herring STW	SY6095082760	Secondary	40	$1.3x10^{10}$*	Unnamed watercourse

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

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.

These two continuous discharges are secondary treated by biological filtration and both discharge indirectly to the Fleet via streams. They are both relatively small and located approximately 8.5 km and 12km from the Fleet production area and as such are likely to have limited impact on the shellfishery.

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

Table II.3: Intermittent discharges within the Fleet catchment

No.	Name	Grid reference	Receiving water	Type
1	Abbotsbury Pumping Station	SY5771285025	Mill Stream	Pumping Station
2	Abbotsbury STW	SY5885584921	Abbotsbury Brook	Storm Overflow
3	Langton Herring	SY6095082760	Unnamed watercourse	Storm Overflow
4	Ferrybridge PS	SY6659376233	The Fleet	Pumping Station
5	Rear Doncaster Road	SY6713077010	Portland Harbour	Storm overflow
6	Hillcrest Road Pumping Station	SY6737077138	Portland Harbour	Pumping Station
7	Castle Cove Pumping Station	SY6768377537	Portland Harbour	Pumping Station
8	Victoria Square Portland	SY6851074503	Portland Harbour	Pumping Station

Data from the Environment Agency

For those without event monitoring it is difficult to assess their potential impacts aside from noting their location and potential to spill untreated sewage. A summary of spill records from the monitored outfalls is presented in Table II.4, covering the period April 2011 to March 2013.

By virtue of its location immediately adjacent to the oyster farm, spill records from the Ferrybridge PS are of most relevance. This pumping station hardly spilled at all, recording only three events totalling about 10 minutes. Its performance therefore suggests that it is unlikely to be of any significance, although its location is a concern. The other more distant monitored overflows, although they were more active than the Ferrybridge PS, only spilled for a very small proportion of the time (<0.1% in all cases). Spill events were actually quite numerous at some, but the vast majority were of a very short duration (a few minutes only). The longest spill recorded was of less than four hours duration.

Table II.4: Summary of spill records, April 2011 to March 2013

Name	Spring			Summer			Autumn			Winter			Total		
	No. events	Total duration (Hrs)	% period active	No. events	Total duration (Hrs)	% period active	No. events	Total duration (Hrs)	% period active	No. events	Total duration (Hrs)	% period active	No. events	Total duration (Hrs)	% period active
Ferrybridge	2	0.03	<0.1%	0	0	0%	0	0	0%	1	0.12	<0.1%	3	0.15	<0.1%
Hillcrest Road	2	0.2	<0.1%	7	0.65	<0.1%	26	2.03	<0.1%	6	2.15	<0.1%	41	5.03	<0.1%
Victoria Square	37	1.45	<0.1%	140	8.08	<0.1%	38	1.26	<0.1%	46	1.53	<0.1%	261	12.3	<0.1%
Castle Cove	9	3.77	<0.1%	3	1.17	<0.1%	2	1.98	<0.1%	10	8.28	<0.1%	24	15.2	<0.1%
Doncaster Road	3	1.6	<0.1%	18	9.52	<0.1%	8	1.4	<0.1%	8	0.97	<0.1%	37	13.5	<0.1%

Data from the Environment Agency

There are also a number of private discharges in the area, some of which discharge to watercourses and some to soakaway/groundwater. For those that discharge to water, these are generally treated by biological filtration, probably via a package treatment plant. The majority of these are small, serving one or two properties but for those that are larger (A, I and L), whilst they will contribute to background levels of contamination, they are located at sufficient distance from the shellfishery to be of limited significance. These discharges are presented in Table II.5.

Table II.5: Details of private sewage discharges

Ref.	Property served	Location	Treatment type	Max. daily flow (m^3/day)	Receiving environment
A	7 Cottages & Restaurant	SY5762084630	Biological Filtration	10.3	Chapel Hill Stream
B	Furlong's Homestead	SY5761085126	Package plant	1	Unnamed Trib of Mill Stream
C	Old Granary	SY6021084720	Biological Filtration	1	Tributary of the Fleet - Partial Soakaway
D	Higher Farm	SY6105084240	Biological Filtration	2	Tributary of the Fleet
E	Fallowhide	SY6118084020	Biological Filtration	1	Trib. Of Rodden Stream - Partial Soakaway
F	The Groom's Cottage	SY6176082710	Biological Filtration	1	Trib. Of Rodden Stream - Partial Soakaway
G	1-7 Coastguard Cottages	SY6059081430	Biological Filtration	3.5	The Fleet
H	Thexton House	SY6230081530	Biological Filtration	1.7	Herbury Steam - Partial Soakaway
I	Moonfleet Manor Hotel	SY6165080510	Biological Filtration	27	The Fleet
J	Oyster Purification Unit	SY6647076260	Sand Filtration	2	East Fleet
K	1 and 2 Seaway Lane	SY5720085170	Biological Filtration	2.5	Soakaway
L	Abbotsbury Swannery	SY5785084440	Biological Filtration	15	Groundwater via Soakaway
M	6 Helston Close	SY6043486109	Septic Tank	1	Groundwater via infiltration stream
N	Highfield	SY6330080380	Biological Filtration	1.4	Soakaway
O	1&2 Butter Street	SY6357080110	Biological Filtration	2	Soakaway
P	Furzedown Farm	SY6516078590	Biological Filtration	1	Soakaway
Q	Ferrybridge Fishermans Stores	SY6672076130	Septic Tank	1	Soakaway
R	No 1 Fishermans Quay	SY6676076080	Septic Tank	1	Soakaway

Data from the Environment Agency.

The discharges closest to the fishery will have the most significance in terms of impact. Ferrybridge PS will be of greatest significance in the event of a storm overflow, but the available spill data indicates that it spilled for less than 10 minutes over the last two years. Ferrybridge Fisherman's Stores and No 1 Fisherman's Quay both discharge to soakaway and provided this is operating correctly, will be of no significance to the fishery. The discharge from the oyster purification plant does not have a sewage content so should be of no impact. In Portland Harbour there are four intermittent discharges that also only spilled very occasionally in recent years. The discharges located further away from the fishery will contribute to background loadings to the Fleet.

Appendix III. Sources and Variation of Microbiological Pollution: Agriculture

The majority of land within the hydrological catchment of the Fleet is devoted to agriculture (Figure 1.2). It is a mix of pasture and arable land, with the land adjacent to the outer reaches occupied by pasture, mainly arable land in the middle reaches, and pastures bordering its upper reaches. Table III.1 presents livestock numbers and densities for the catchment. These data were provided by Defra and are derived from the June 2010 census as this provides more details than censuses undertaken in 2011 and 2012. Geographic assignment of animal counts in this dataset is based on the allocation of a single point to each farm, whereas in reality an individual farm may span the catchment boundary. Nevertheless, Table III.1 should give a reasonable indication of the numbers and types of livestock within the catchment.

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

Cattle		Sheep		Pigs		Poultry	
No.	Density (no/km^2)	No.	Density (no/km^2)	No.	Density (no/km^2)	No.	Density (no/km^2)
1,454	49.2	**	**	**	**	**	**

*** Data withheld to prevent disclosure of information on individual farms*
Data from Defra

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

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

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

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

Contamination of livestock origin will either be deposited directly on pastures by grazing animals, or collected from operations such as cattle sheds and poultry houses and spread on both arable land and pasture. This in turn will enter watercourses which will carry it to coastal waters. As the primary mechanism for mobilisation of faecal matter deposited on pastures into watercourses is via land runoff, fluxes of agricultural contamination into coastal waters will be highly rainfall dependent. Peak concentrations of faecal indicator bacteria in watercourses are likely to arise when heavy rain follows a significant dry period (the ‘first flush’).

Table III.1 indicates that there are potentially significant numbers of cattle within the catchment. The extent of their impacts on the oyster farm will depend largely on where they are grazed, and the degree to which they are able to access watercourses draining to the Fleet. Shoreline survey livestock observations included only a few horses on fields behind Martleaves Bay, although the local topography may have obscured some areas. The empty fields between the Chesil Holiday Park and the Bridging Camp will be used for grazing livestock on at times.

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

Appendix IV. Sources and variation of microbiological pollution: Boats

The discharge of sewage from boats is a potential source of bacterial contamination of shellfisheries within the Fleet. Although boat traffic within the Fleet lagoon is relatively low, there is significant boat traffic in Portland Harbour to which the Fleet is connected. Figure IV.1 presents an overview of boating activity derived from the shoreline survey, satellite images and various internet sources.

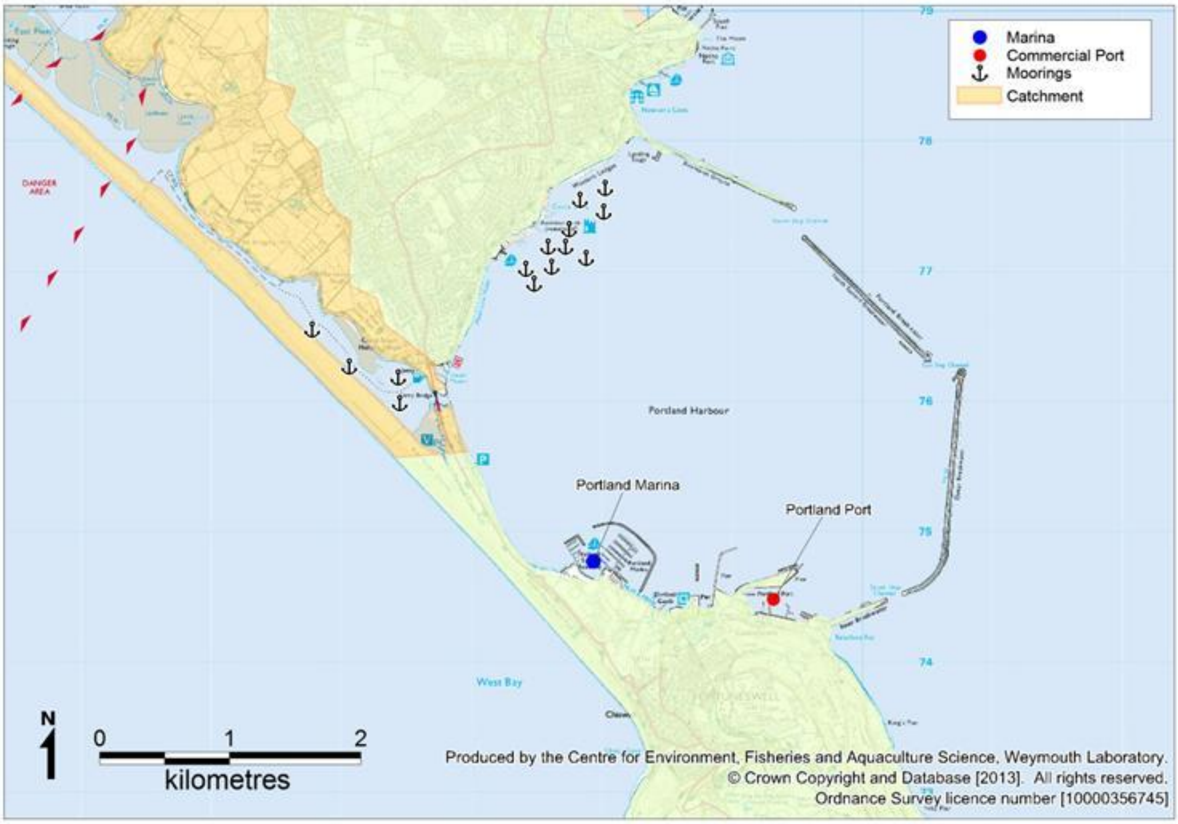


Figure IV.1: Boating activity within the Fleet and Portland Harbour

Portland Harbour is the second largest man made harbour in the world. It is a busy commercial port dealing mainly with dry bulk with around 650 large vessels docking in Portland Harbour each year (BBC News, 2013).It is also a popular cruise port, with around eleven cruise ships docking in the harbour each year (Portland Port Authority website, 2013). Merchant shipping vessels are not permitted to make overboard discharges within 3 nautical miles of land[1] so vessels associated with the commercial port should be of no impact.

---

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

There is a large commercial fishing fleet (around 84) in Weymouth and Portland, with the majority operating out of Weymouth (Walmsley and Pawson, 2007). However, fishing from boats is prohibited in the Fleet due to its designation as a bass nursery area.

There is one marina within the harbour with 560 annual berths and alongside berths for several super yachts. There are some moorings for smaller craft in the east Fleet and seasonal moorings for yachts and cabin cruisers off Castle Cove and Osprey Quay. Boats moored within the Fleet generally appeared too small to contain onboard toilets. Sewage pump out facilities are available in Portland Harbour (The Green Blue, 2010) and a byelaw prohibits the discharge of any matter into the harbour (The Portland Harbour Revision Order 1997) although how strictly this is adhered to is uncertain.

Sailing and watersports are popular within Portland harbour. The Olympic sailing in 2012 was hosted by Portland Sailing Academy and is a popular venue for international and national sailing events. Windsurfing, kite surfing and kayaking are also popular watersports within the sheltered harbour walls. However, the smaller recreational boats are not large enough to contain onboard toilet facilities and therefore are unlikely to make overboard discharges.

Private vessels such as yachts, motor cruisers and fishing vessels of a sufficient size are likely to make overboard discharges in the area from time to time, despite the local byelaw prohibiting such discharges. This may be most likely to occur when the boats are moored or at anchor, particularly if they are in overnight occupation. The areas that are at highest risk from microbiological pollution therefore include the mooring areas for larger private vessels which are situated by Castle Cove and Osprey Quay. 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.

Appendix V. Sources and Variation of Microbiological Pollution: Wildlife

The Fleet features a variety of habitats including a large pebbled beach, saltmarsh, eelgrass beds, intertidal flats and these attract significant populations of wildlife including large numbers of internationally and nationally important species of birds. Consequently, the whole of the Fleet has been designated as a Site of Special Scientific Interest (SSSI), Special Protection Area (SPA) and Special Area of Conservation (SAC). It has also been designated as a Ramsar site, a Nature Reserve and the west Fleet forms part of an Area of Outstanding Natural Beauty (AONB) (Langston et. al, 2003).

The most significant wildlife aggregation in terms of shellfish hygiene is likely to be overwintering waterbirds (waders and wildfowl). Studies in the UK have found significant concentrations of microbiological contaminants (thermophilic Campylobacter, salmonellae, faecal coliforms and faecal streptococci) from intertidal sediment samples supporting large communities of birds (Obiri-Danso and Jones, 2000). The Fleet and Portland Harbour support large numbers of the internationally important species, the Mute swan, overwintering Dark-bellied Brent Goose and nationally important species such as, Red Breasted Mergaser, Pochard and Coots. An average total count of 15,873 waterbirds (wildfowl and waders) was reported over five winters up to 2010/11 for the Fleet and Wey (Holt *et. al*, 2012). A study undertaken by Holt et.al, in 2009/2010 revealed that at low tide oystercatchers frequented the intertidal areas primarily in the central Fleet while Red-Breasted Merganser were present throughout the Fleet and Portland Harbour. Teal, Wigeon and Coot mainly frequented the less tidal area in the northern reaches close to Abbotsbury (Holt *et. al*, 2011).

Geese and ducks will mainly frequent saltmarsh, grasslands, and intertidal eelgrass beds 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 invertebrates and will deposit faeces directly on the intertidal areas, including amongst the oyster trestles. Waders may tend to aggregate in certain areas holding the highest densities of prey of their preferred size and species, but this will probably vary from year to year. At high tide waders are likely to frequent the saltmarsh and the perimeter of the Fleet, possibly exhibiting a preference for the Chesil Beach side where disturbance from humans and predators is likely to be lower. 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 a total of 95 pairs of Little Tern, Herring gulls and Great Black-backed Gull within the Fleet and the surrounding areas (Mitchell *et al*, 2004). 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. At certain states of the tide they will rest on the trestles, and so may defecate directly onto the oyster bags.

The oldest managed population of about 850 Mute swans is located in the upper reaches of the Fleet, in Abbotsbury (Langston *et. al*, 2003), where they are provided with safe nesting enclosures and fed daily. They are present all year round, although they may be more dispersed outside of the spring/summer breeding season. They will contribute to the levels of faecal indicator bacteria in the Fleet, although whether they are of any significance to the oyster farm is uncertain, given the distance between the two.

There are no major seal colonies in the vicinity of the Fleet, and the closest colony is in the Solent (SCOS, 2012). Whilst there may be occasional seal sightings as these animals forage widely, they will not be a significant source of contamination to the shellfishery. No other wildlife species which may have a bearing on the sampling plan have been identified.

Domestic animals

Dog walking takes place on beaches/intertidal areas 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 closer to the more urban areas. As a diffuse source, this will have little influence on the location of RMPs.

.

Appendix VI. Meteorological Data: Rainfall

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

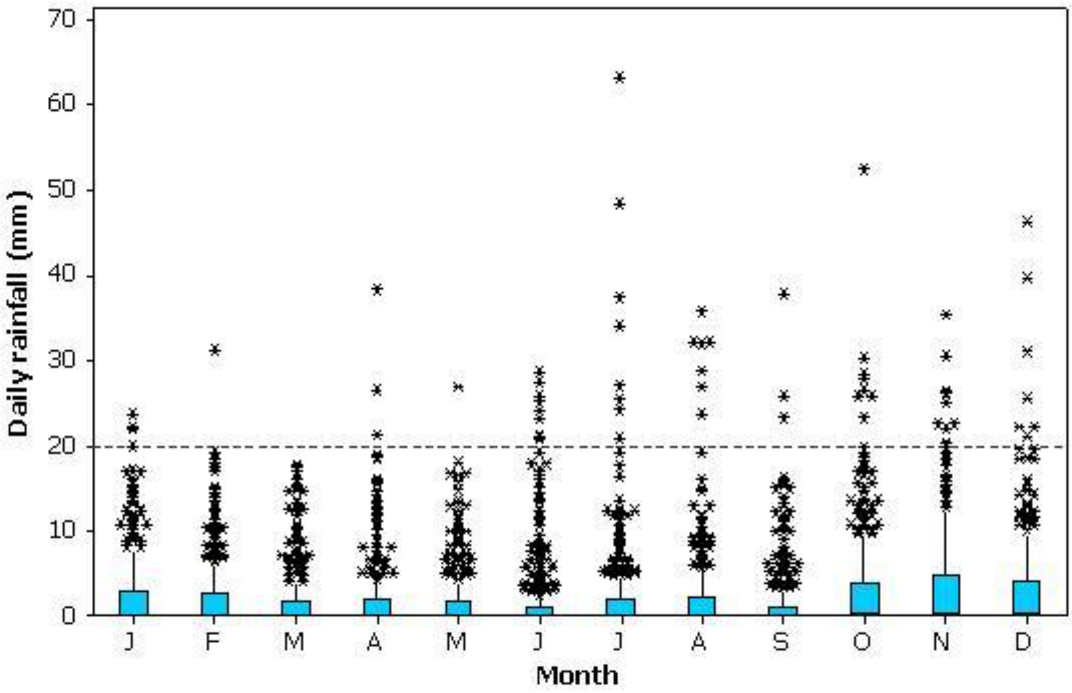


Figure VI.1: Boxplot of daily rainfall totals at Friar Waddon, January 2003 to December 2012.
Data from the Environment Agency

Rainfall records from Friar Waddon, which is representative of conditions in the vicinity of the oyster farm, indicate a relatively limited seasonal variation in average rainfall. However there was slightly more rainfall in the second half of the year (July to December) than the first half of the year (January to June). Rainfall was lowest on average from February to April and highest on average in October. Daily totals of over 20mm were recorded on 1.6% of days and 48% of days were dry. High rainfall events occurred in all months except May and were more frequent in the second half of the year.

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

Appendix VII. Meteorological Data: Wind

Southern England is one of the more sheltered parts of the UK, the windiest areas being in western and northern Britain, closer to the Atlantic. 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 half of the year, especially from December to February, and this is when mean speeds and gusts (short duration peak values) are strongest (Met Office, 2012).

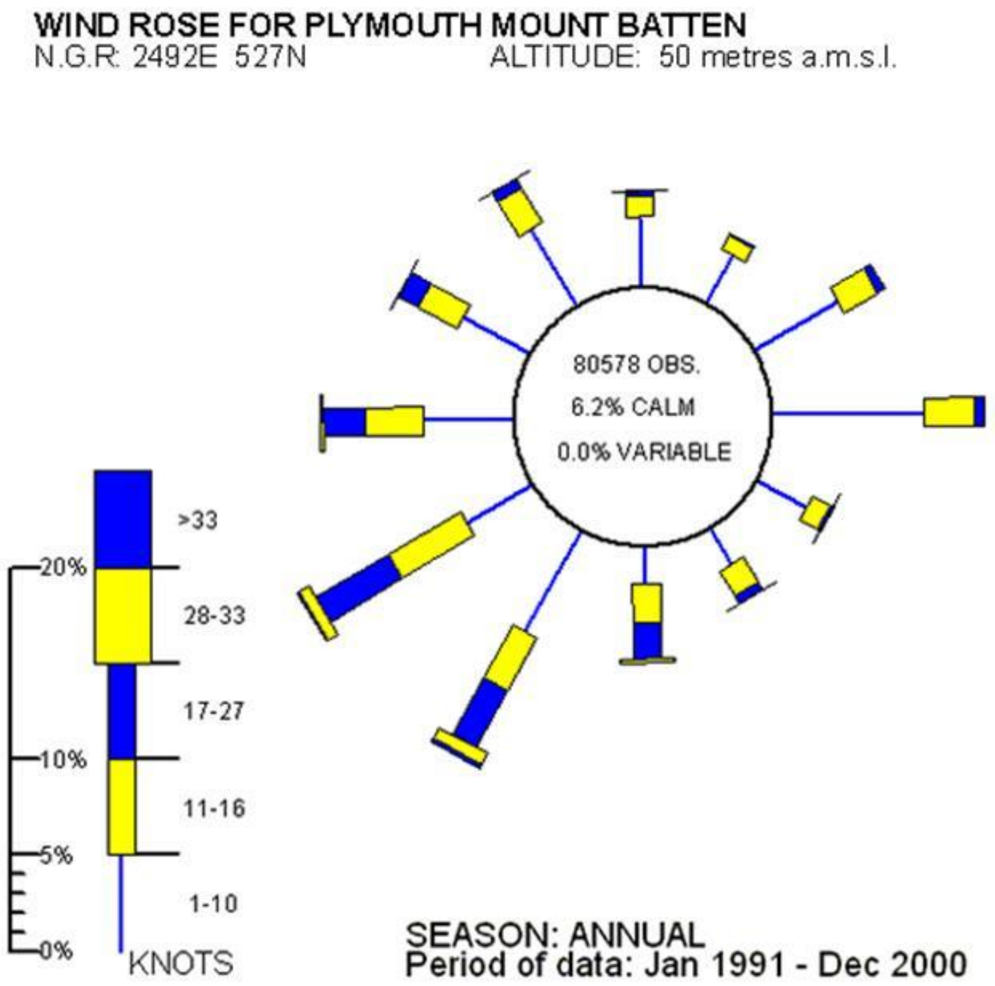


Figure VII.1: Wind rose for Plymouth

Produced by the Meteorological Office. Contains public sector information licensed under the Open Government Licence v1.0

The wind rose illustrates the typical frequency of speed and direction throughout a year and confirms a prevailing south westerly wind. The Fleet is an enclosed coastal lagoon which is afforded some protection from the prevailing winds. It has a narrow opening which faces east and flows into Portland Harbour. It is sheltered to the west by Chesil Beach spit which rises up to 14 m in height (Langston et. al, 2003). The Isle of Portland is situated south of the Fleet and offers some protection from winds derived from the south. Elevated land to the east and north west provides shelter to the Fleet from north/easterly winds. Winds from the north west and south east will blow along its length, and therefore have the greatest potential to affect water circulation patterns.

Appendix VIII. Hydrometric Data: Freshwater Inputs

The Fleet has a relatively small catchment of about 28km^2 in total. No major freshwater inputs flow into the Fleet however there are seven streams that drain into it (Figure VIII.1).

Figure VIII.1: Freshwater Inputs into the Fleet

The catchment is predominantly rural, non irrigated arable land and pasture with small areas of urbanised land in the upper catchment. The hydrogeology of the catchment ranges from very low permeability to high permeability, with the areas adjacent to the oyster farm being a mix of moderate and very low permeability (NERC, 2012). Land bordering the middle reaches of The Fleet and some parts of the upper reaches are of high permeability, so there are likely to be groundwater flows here.

There are seven spot flow gauging stations present within the catchment; mean flows for these are presented in Table VIII.1. It is apparent that the discharge rates from these streams are minor, although the data available is not fully representative as the sampling is sporadic and the number of recordings taken is low. As a result, an assessment of seasonality in discharge volumes cannot be made. East Fleet and West Fleet streams are winterbournes and therefore dry out over the summer, for a period of about 3-4 months (Johnston and Gilliland, 2000).

Seasonal variation of rainfall is relatively limited but the highest rainfall on average was during the colder months of October to January (see Appendix VI). Flow rates generally tend to be higher during and after heavy rainfall events and therefore it could be presumed that there is a seasonal variation in flow rates. However, the seasonal pattern of flows will not be 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 watercourses, allowing contamination from more distant sources to have an increased impact during high flow events.

Table VIII.1: Summary flow statistics for spot flow gauging stations draining into the Fleet (1975 - 2001)

Station Name	Stream name	No. samples	Mean Flow (m^3s-1)	Max Flow (m^3s-1)
Coward's Lake	Coward's Lake	10	0.020	0.038
Abbey Barn	Mill	11	0.047	0.071
Portesham	Horsepool	12	0.037	0.060
Horsepool	Horsepool	10	0.037	0.058
Mixen Plantation	Rodden	10	0.030	0.085
Moonfleet Manor	West Fleet	10	0.001	0.003
East Fleet	East Fleet	9	0.003	0.010

Data from the Environment Agency

Table VIII.2: Summary flow statistics cited in Langston et.al, 2003

Stream name	Mean Flow (m^3s-1)
Coward's Lake	0.03
Mill	0.086
Horsepool	0.026 (0.035)
Horsepool	0.026 (0.035)
Rodden	0.053
West Fleet	0.018
East Fleet	0.027

During the shoreline survey, which was conducted under wet conditions, only one very small watercourse was encountered. It discharges to the head of a small embayment about 600 m past the western end of the trestle site. Its discharge was minor at $43m^3$/day, but was carrying a high concentration of *E. coli* (9000 cfu/100ml). The bacterial loading it was generating at the time was only $3.8x10^9$ *E. coli*/day.

Appendix IX. Hydrography

IX.1. Bathymetry

The Fleet is a shallow coastal lagoon bordered by a large shingle barrier, Chesil Beach, which flows into Portland Harbour and subsequently into the English Channel. It covers an area of approximately 5km² of which a high proportion is intertidal. Figure IX.1 shows an aerial photograph of the outer reaches of the lagoon (reproduced from Bing) within which the shellfish beds are located. Admiralty charts are not presented due to a lack of detail.

Figure IX.1: Aerial photograph of the East Fleet Lagoon
Bing, 2010

Maximum depths of 3.8m (Admiralty chart, 2255) are seen in the constricted channel at Ferrybridge, which connects the Fleet to Portland Harbour and in The Narrows, a constriction where scouring occurs from strong tidal currents (Figure IX.1). These strong tidal flows will promote turbulent mixing of the water column. The Fleet is about 13km in length from its mouth at Ferrybridge to its head at Abbotsbury. Its width ranges from 900m at Littlesea to 65m at its narrowest point (The Narrows). There is a subtidal channel between Ferrybridge and Narrows which runs along the base of Chesil Beach. The majority of intertidal areas are to the north of this channel, although there is a large area of intertidal flats south of the channel just inside Ferrybridge.

IX.2. Tides and Currents

Currents in coastal waters are predominantly driven by a combination of tide, wind and freshwater inputs. Table IX.1 presents tidal information for Portland, the nearest station for which tidal predictions are available.

Table IX.1 Tide Levels and ranges within Portland Harbour, situated east of the Fleet

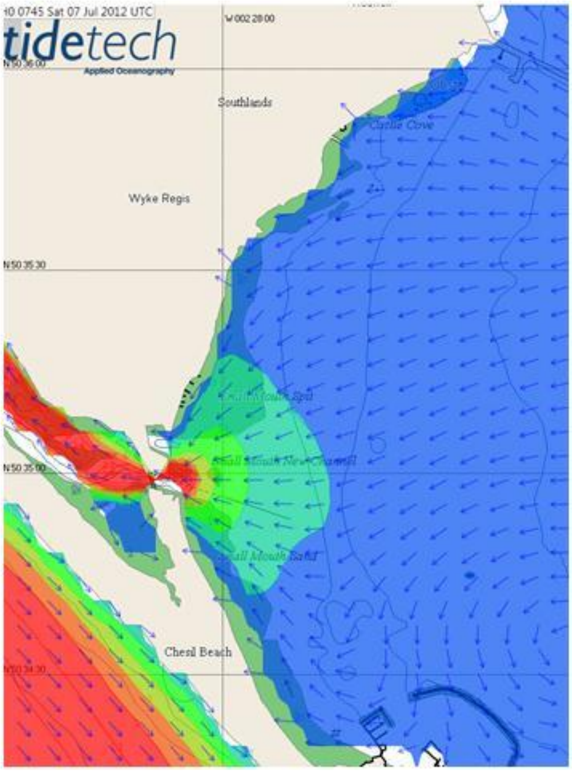
	Height above chart datum (m)				Range (m)	
Port	MHWS	MHWN	MLWN	MLWS	Spring	Neap
Portland	2.1	1.4	0.8	0.1	2.0	0.8

Data from Admiralty Total Tides

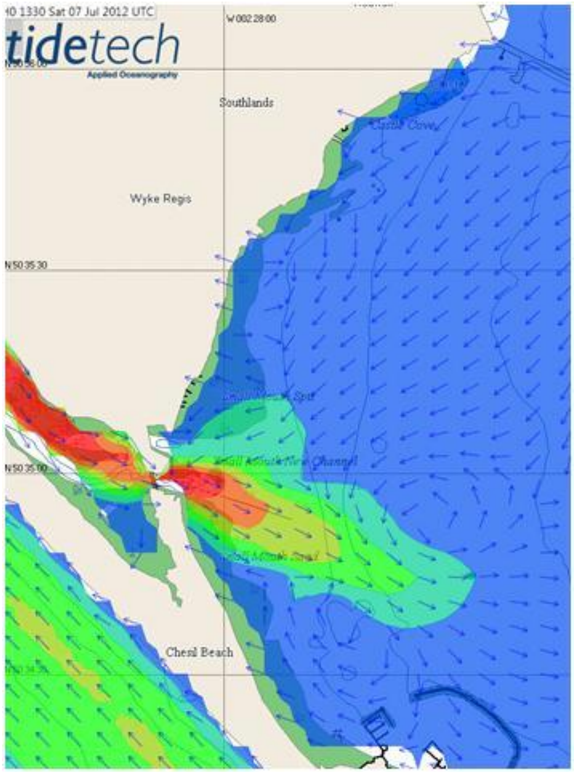
Portland Harbour has a small tidal range. The tidal curve indicates a there are two low waters, which are about 3 hours apart. Around this time there will be little water movement outside of the constrictions at the Narrows and Ferrybridge. Tidal range decreases significantly towards the upper reaches of the Fleet, but is similar to that of Portland Harbour in the vicinity of the oyster farm. As such, there will be less tidal flushing of the upper reaches compared to the area between The Narrows and Ferrybridge where the oyster farm is located. Robinson, 1983, indicates that flushing times are in the order of 1 or 2 days in the lower reaches of the Fleet whereas they range from 10-40 days at Abbotsbury. [2]

There are no tidal diamonds available for the Fleet. Tidal streams flood up the lagoon in a north westerly direction, following the main channel and ebb in the opposite direction. Figure IX.2 shows modelled tidal vectors on flood and ebb tides. These suggest that tidal currents are quite strong in the outer reaches of the Fleet across the oyster farm, generally exceeding 1 knot (or around 0.5 m/s) throughout. They also indicate a 'dead spot' on the intertidal area immediately south of Ferrybridge. Tidal currents within Portland Harbour are generally very weak away from Ferrybridge and the harbour entrances.

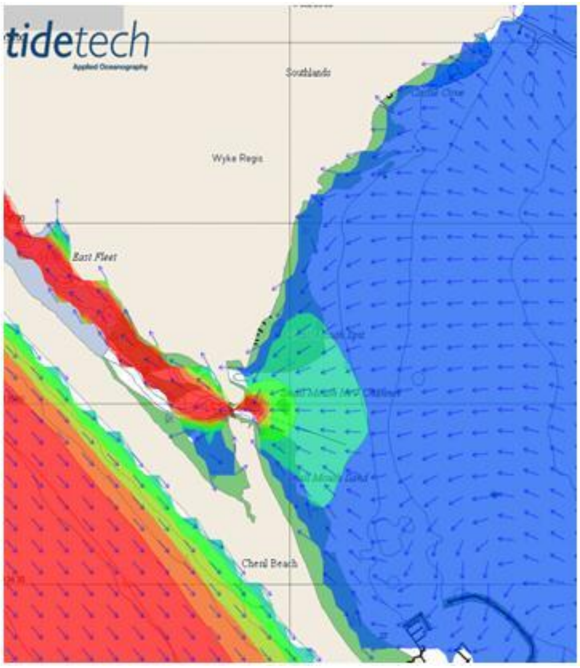
[2] Flushing time is the time for 90% of the water to be flushed out of a system



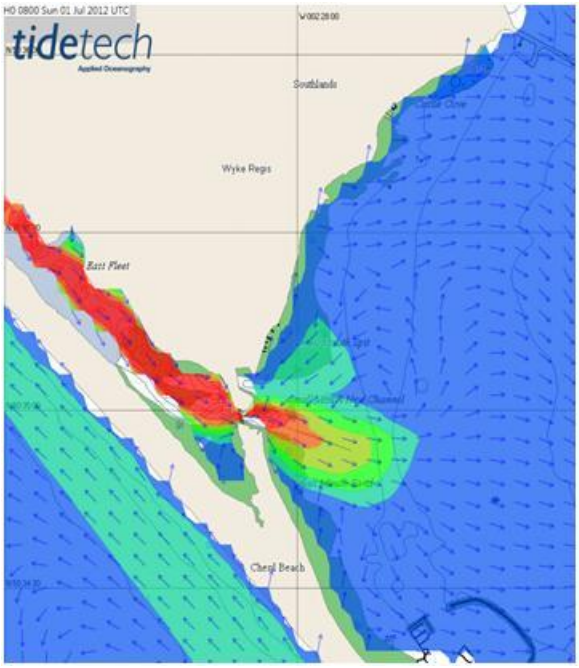
Spring Tide - Flood



Spring Tide - Ebb



Neap Tide - Flood



Neap Tide - Ebb

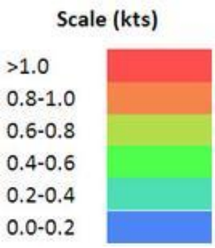


Figure IX.2: Modified images of modelled peak current velocity and direction of tidal streams on spring and neap flood tides within the East Fleet

(Produced by tidetech using Expedition Software [www.expiditionmarine.com], 2012)

The flood tide will carry contamination from sources in Portland Harbour and the ebb tide will carry contamination from shoreline sources further up in the lagoon. A dispersion model (PLUME-RW) applied to the tidal model by HR Wallingford was used to assess the tidal flushing in Portland Harbour (presented in Cefas, 2009). Particles were released for an hour at spring high water at six locations and the model run over six spring tides. Two locations where particles were released were east of Castle Cove on the north west of Portland Harbour and just east of the Small Mouth. Particles released at Fleet mouth were carried as far as the Narrows within an hour of being released and had become dispersed after a half tide whereas particles released at Castle Cove were carried south along the coast and after one tidal cycle had been carried west into the Fleet almost as far as the Narrows. Consequently, sources of microbiological contamination from northeast shore of Portland Harbour could reach the shellfish beds during the course of a flood tide. Particles released from the Osprey Quay area did not reach The Fleet until three tides later, and particles from the Portland Port area were flushed out the harbour and did not come near The Fleet. As such, sources here are likely to be of little significance to the oyster farm within The Fleet.

In addition to tidally driven currents, are the effects of freshwater inputs and wind. There are several small freshwater inputs that discharge into the Fleet, and these, combined with the shallow and enclosed nature of the lagoon, and the decreasing tidal amplitude in its upper reaches result in a gradient of decreasing salinity west of The Narrows (Figure IX.3 and Figure IX.4). Whilst this may result in some density driven circulation in the upper reaches east of the narrows salinity is approaching that of full strength seawater throughout. The salinity gradient varies with rainfall and tidal cycles, but to the east of The Narrows it always approaches that of full strength seawater (Robinson, 1983)

Also, there is considerable potential for turbulent mixing of the water column where it passes through the narrows. As such, density driven circulation is unlikely to be of significance in the vicinity of the oyster farm, particularly given the relatively strong tidal streams in this area. The geographical pattern of salinity is likely to reflect that of runoff borne contamination. The gradient is more marked in the upper reaches of The Fleet, but barely noticeable between The Narrows and Ferrybridge, where it increases on average from 33.7 to 34.3 over a 2km distance. It may result in very slightly higher average levels of contamination towards the western end of the site. Seawater from the English Channel can percolate through the pebbles of Chesil Beach and into the Fleet under certain tidal conditions, which can affect salinity particularly in the east Fleet. This does not generally occur to a significant extent, except in exceptional weather conditions (Robinson, 1983).

Figure IX.3: Salinity sampling locations within the Fleet

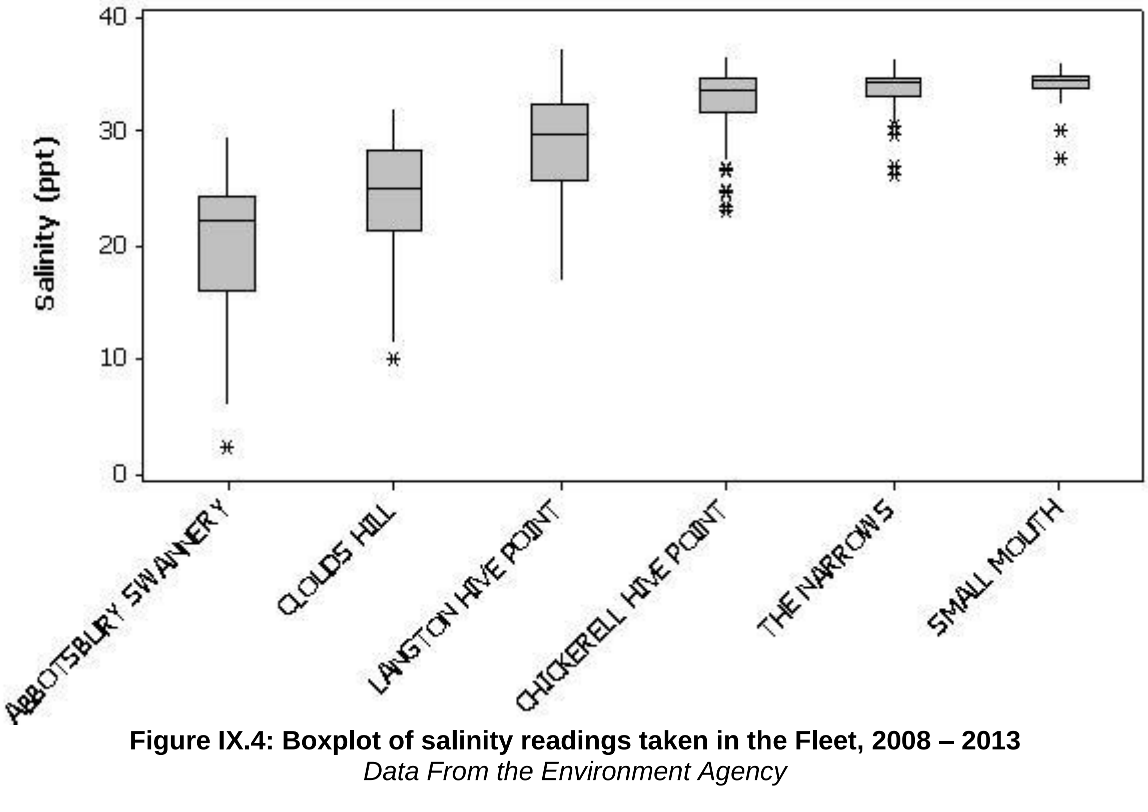


Figure IX.4: Boxplot of salinity readings taken in the Fleet, 2008 – 2013
Data From the Environment Agency

Strong winds will modify surface currents. Winds typically drive surface water at about 3% of the wind speed (Brown, 1991) so gale force wind (34 knots or 17.2 m/s) would drive a surface water currents which may travel lower in the water column or along sheltered margins. The lagoon is most affected by winds from the southeast and north west, which will blow along its length. Exact effects are dependent on the wind speed and direction as well as state of the tide and other environmental variables so a great number of scenarios may arise. Winds are likely to significantly affect water circulation where tidal currents are sluggish, such as within Portland Harbour and the upper reaches of The Fleet. Where strong winds blow across a sufficient distance of water they may create wave action, and where these waves break contamination held in intertidal sediments may be resuspended, although given the enclosed nature of the Fleet wave action only generally occurs during southeasterly and northwesterly winds (Langston et. al, 2003).

Appendix X. Microbiological Data: Seawater

X.1. Shellfish Waters

Summary statistics and geographical variation

There are three shellfish waters sites designated under Directive 2006/113/EC (European Communities, 2006) in the Fleet and Portland Harbour. Figure X.1 shows the location of these sites and their monitoring points. The Portland Harbour West shellfish water has had two monitoring points in the past, but now only has one. Table X.1 presents summary statistics for bacteriological monitoring results and Figure X.2: Box-and-whisker plots of all faecal coliforms results presents a boxplot of faecal coliforms levels from the monitoring point.

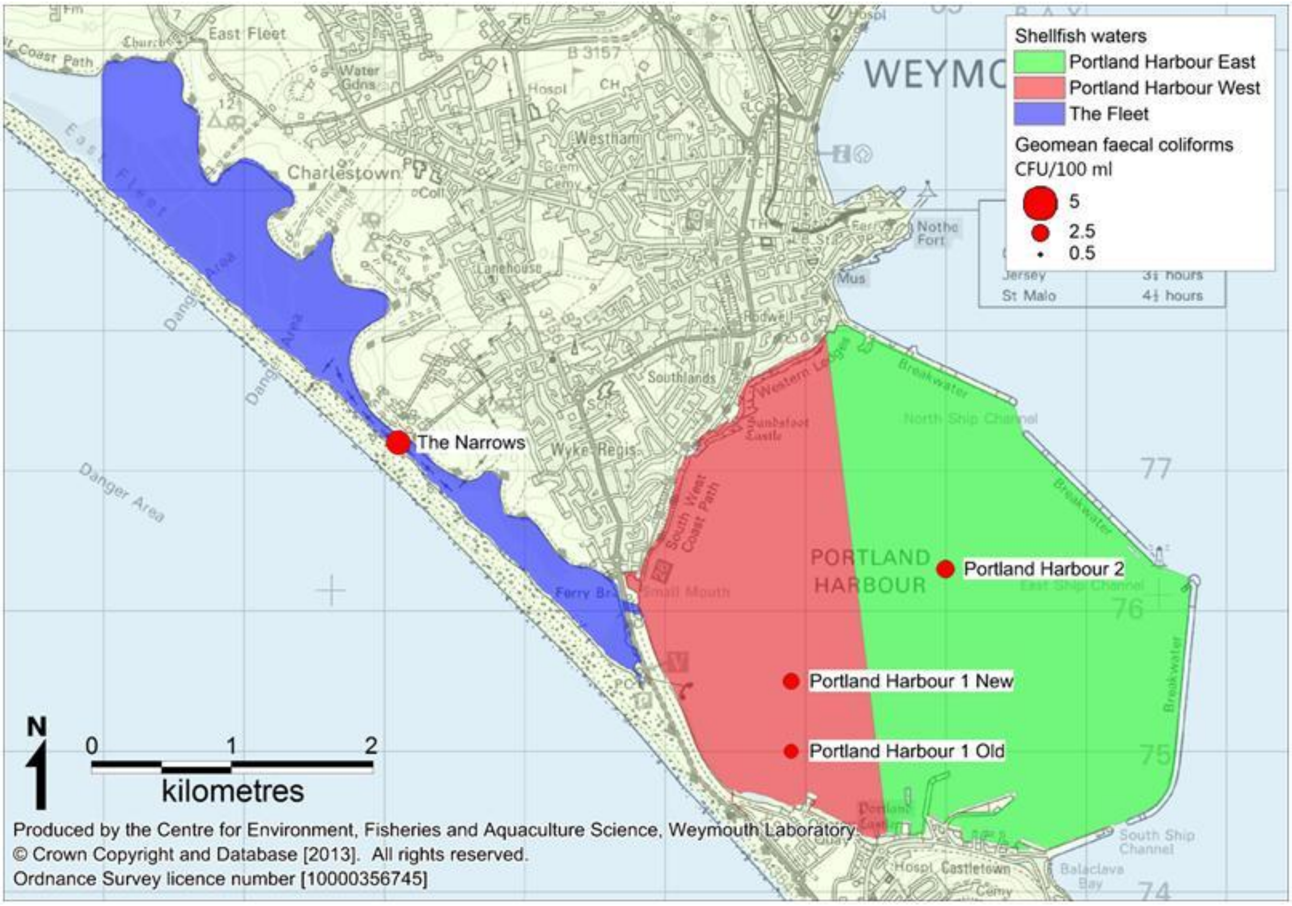


Figure X.1: Location of monitoring points around the Fleet and Portland Harbour.

Table X.1: Summary statistics for shellfish waters faecal coliform results, 2008 to 2013 (cfu/100ml).

Site	No.	Date of first sample	Date of last sample	Geometric mean	Min.	Max.
The Narrows	22	28/01/2008	21/02/2013	3.6	<2	61
Portland Harbour 1 New	23	30/06/2008	19/04/2013	2.4	<2	20
Portland Harbour 1 Old	9	30/06/2008	10/02/2010	2.1	<2	15
Portland Harbour 2	23	30/06/2008	19/04/2013	2.7	<2	16

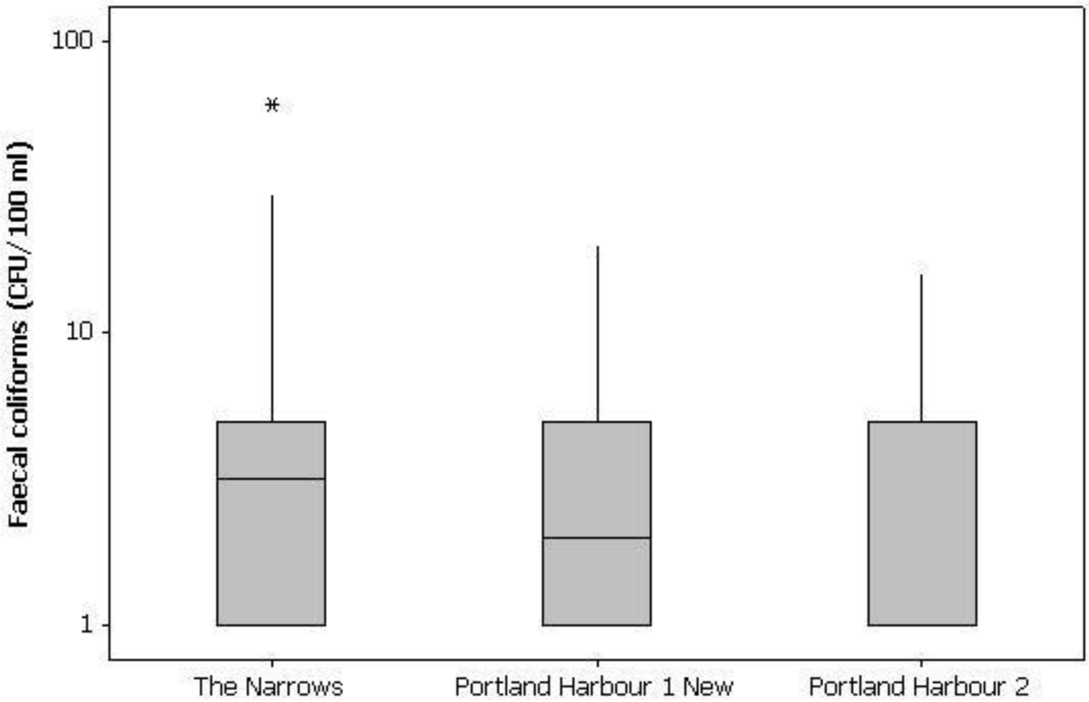


Figure X.2: Box-and-whisker plots of all faecal coliforms results
Data from the Environment Agency

Levels of faecal indicator bacteria were generally low at all four sampling locations. Portland Harbour 1 Old only had nine samples and will therefore not be considered in the following statistical analyses. Statistical comparisons (one-way ANOVA) showed that there were no significant differences in faecal coliforms between the three sites ($p = 0.357$) for which data is presented in Figure X.2. The Narrows had slightly higher average and peak levels of contamination compared to the locations within Portland Harbour, where results were very similar throughout.

Comparisons of sites 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. Only Portland Harbour 1 new and Portland Harbour 2 shared at least 20 sampling dates. A significant ($p < 0.05$) correlation was found between these sites, indicating that they share similar sources for contamination.

Overall temporal pattern in results

The overall variation in faecal coliform levels found at shellfish water sites is shown in Figure X.3.

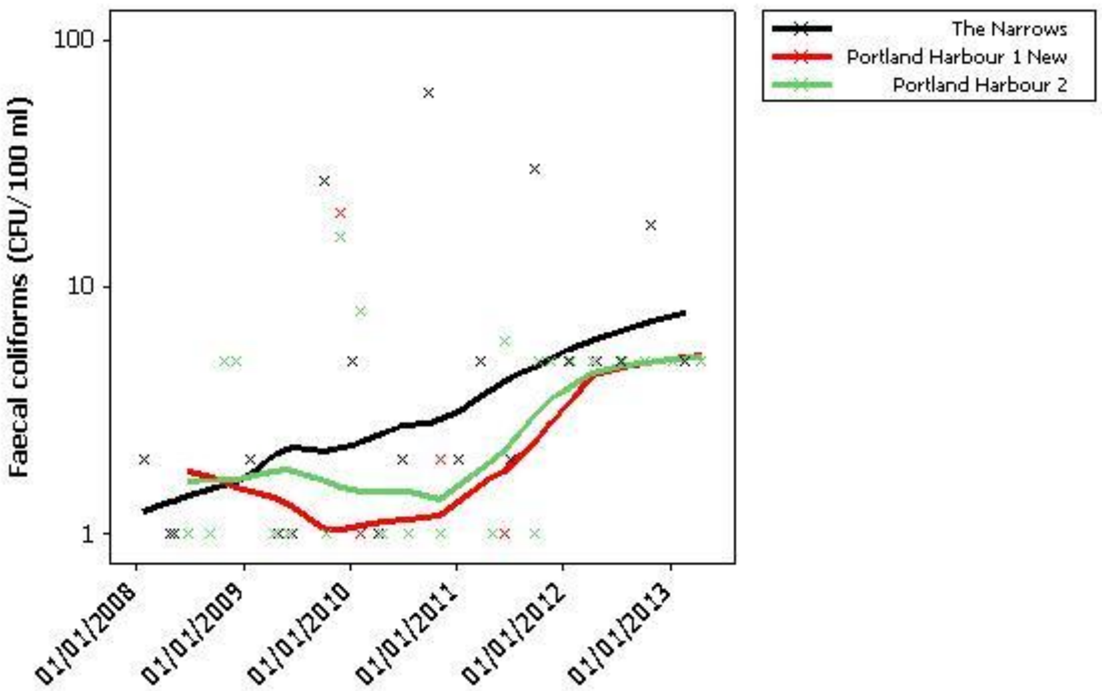


Figure X.3: Scatterplot of faecal coliform results by date, overlaid with loess lines
Data from the Environment Agency

Figure X.3 suggests that faecal coliform levels at all three sites have increased on average since 2008. . However, faecal coliform levels at the Portland Harbour sites did not start to increase until 2011.

Seasonal patterns of results

Comparisons (One-way ANOVA) of faecal coliform levels revealed that there was a significant difference between seasons at the Narrows ($p < 0.001$) but not at Portland Harbour 1 New or Portland Harbour 2 ($p = 0.170$ and 0.063 respectively). Post ANOVA Tukey tests revealed that at the Narrows faecal coliform levels were significantly higher in the autumn than in any of the other seasons.

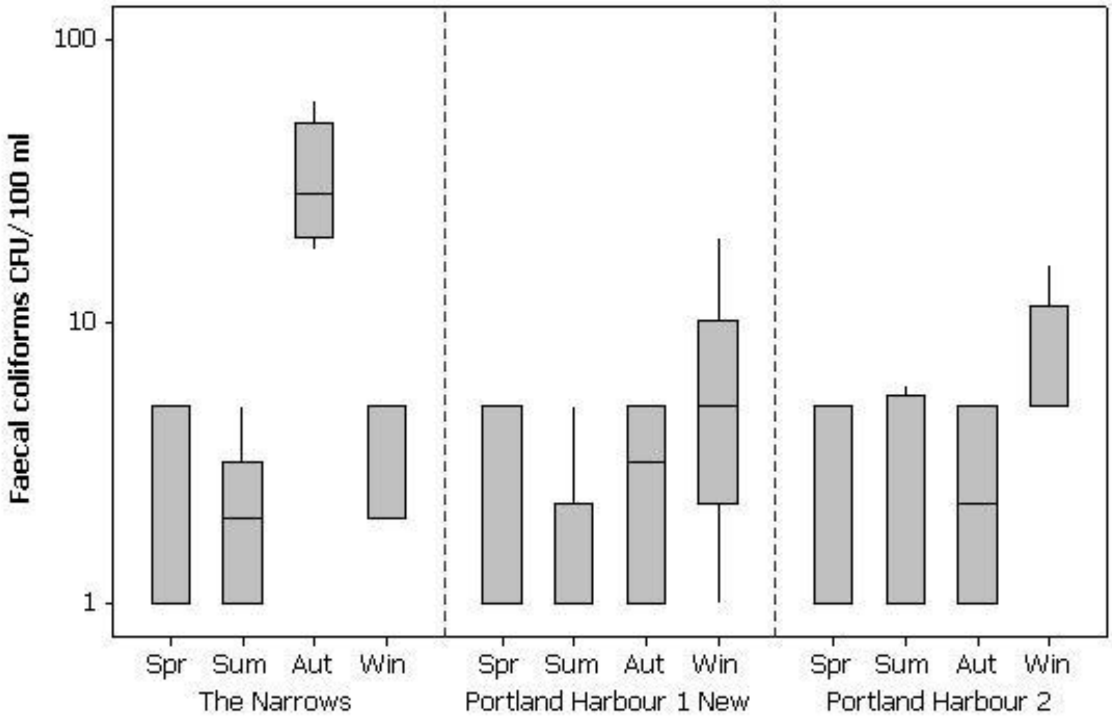


Figure X.4: Boxplot of faecal coliform results by site and season
Data from the Environment Agency

Influence of tide

There were not enough data to analyse tidal effects.

Influence of rainfall

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

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

	Site	The Narrows	Portland Harbour 1 New	Portland Harbour 2
	n	21	21	21
24 hour periods prior to sampling	1 day	0.454	0.284	0.341
	2 days	0.104	0.638	0.485
	3 days	0.283	0.687	0.427
	4 days	0.072	0.183	0.333
	5 days	-0.209	-0.165	0.053
	6 days	-0.424	0.076	0.382
	7 days	-0.102	0.208	0.262
Total prior to sampling over	2 days	0.227	0.467	0.442
	3 days	0.296	0.574	0.487
	4 days	0.282	0.508	0.462
	5 days	0.187	0.400	0.404
	6 days	0.000	0.383	0.571
	7 days	0.042	0.275	0.485

Data from the Environment Agency

Rainfall had a rapid but short lived affect on faecal coliform levels at the Narrows. At the Portland Harbour sites, rainfall took longer to influence faecal coliform levels, but the effect was longer lived than in the Fleet.

Influence of salinity

Pearson's correlations were run to determine the effect of salinity on faecal coliforms at shellfish waters sites. No significant correlations between salinity and faecal coliforms was observed (p = 0.213 to 0.567), although there was little variation in salinity at the monitoring points within Portland Harbour.

Appendix XI. Microbiological Data: Shellfish Flesh Hygiene

XI.1. Summary statistics and geographical variation

There are a total of 10 RMPs in the Fleet and Portland Harbour that have been sampled between 2003 and 2013. Only one of these RMPs (Fleet Oyster Farm) is located in the Fleet.

The geometric mean results of shellfish flesh monitoring from all RMPs sampled from 2003 onwards are presented in Figure XI.1. Summary statistics are presented in Table XI.1 and boxplots for sites are shown in Figure XI.2 to Figure XI.4. The Harbour (Several Order) mussel, Portland Harbour (Several Order) native oyster and the Wyke palourde RMPs were all sampled on fewer than ten occasions and will not be considered in the more detailed analyses.

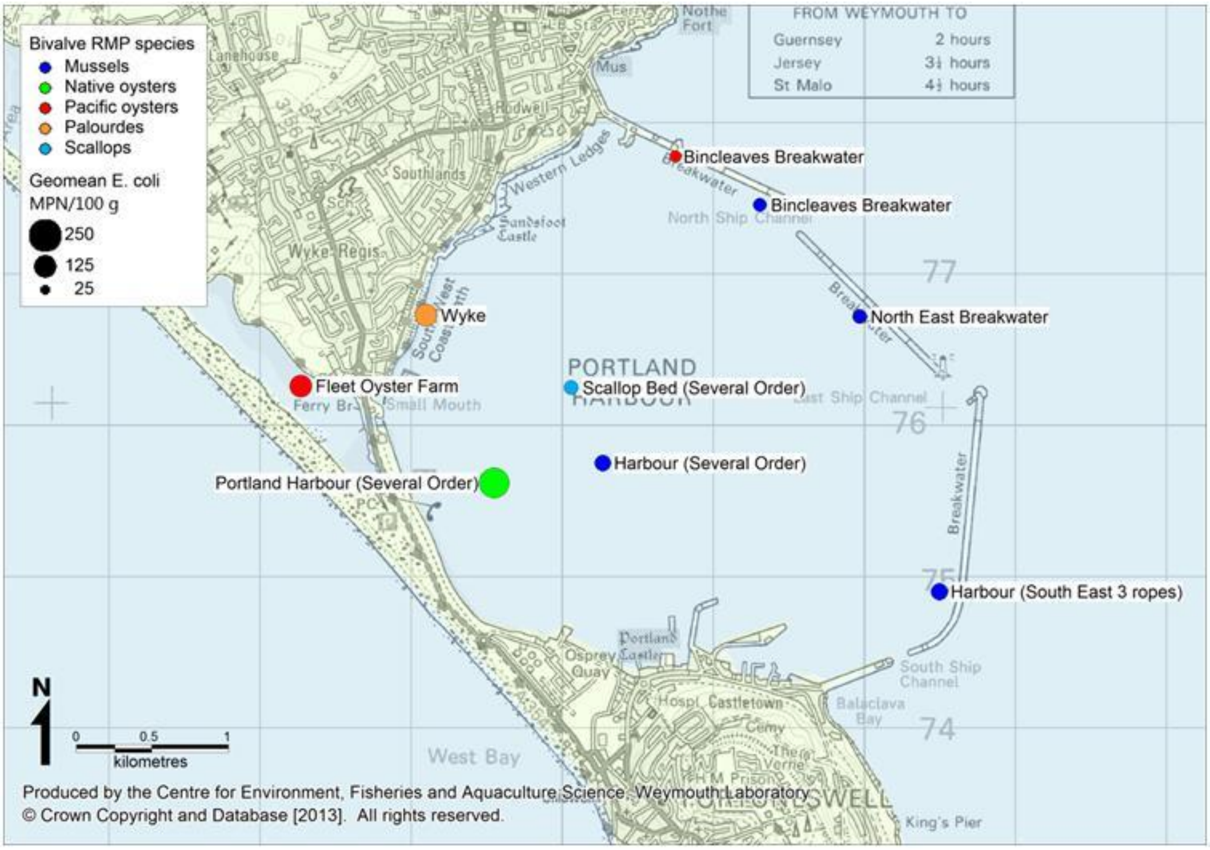


Figure XI.1: Bivalve RMPs active since 2003

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

Site	Species	No.	Date of first sample	Date of last sample	Geometric mean	Min.	Max.	% over 230	% over 4,600
Harbour (Several Order)	Mussel	9	14/01/2003	29/06/2004	74.8	<20	500	22.2	0.0
Bincleaves Breakwater	Mussel	71	21/06/2005	09/02/2011	55.8	<20	5400	19.7	2.8
North Eastern Breakwater	Mussel	33	17/01/2011	09/09/2013	52.7	<20	1100	12.1	0.0
Harbour (South East 3 ropes)	Mussel	62	14/01/2003	05/05/2009	79.4	<20	5400	21.0	1.6
Portland Harbour (Several Order)	Native oyster	1	29/05/2009	29/05/2009	230.0	230	230	100.0	0.0
Fleet Oyster Farm	Pacific oyster	125	21/01/2003	03/09/2013	133.4	<20	9200	30.4	2.4
Bincleaves Breakwater	Pacific oyster	54	25/09/2007	09/02/2011	40.0	<20	1100	13.0	0.0
North East Breakwater	Pacific oyster	27	21/03/2011	09/09/2013	60.2	<20	6300	22.2	3.7
Wyke	Palourde	1	22/06/2011	22/06/2011	130.0	130	130	0.0	0.0
Scallop Bed (Several Order)	Scallops	69	14/01/2003	09/09/2013	58.0	<20	1700	15.9	0.0

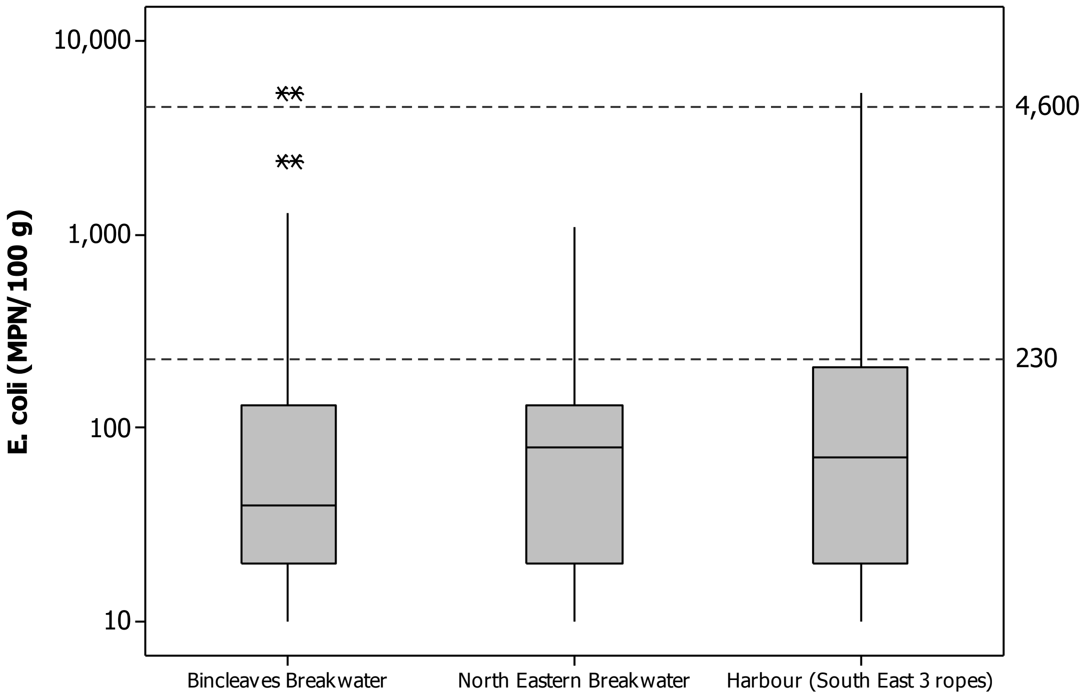


Figure XI.2: Boxplots of *E. coli* results from mussel RMPs from 2003 onwards.

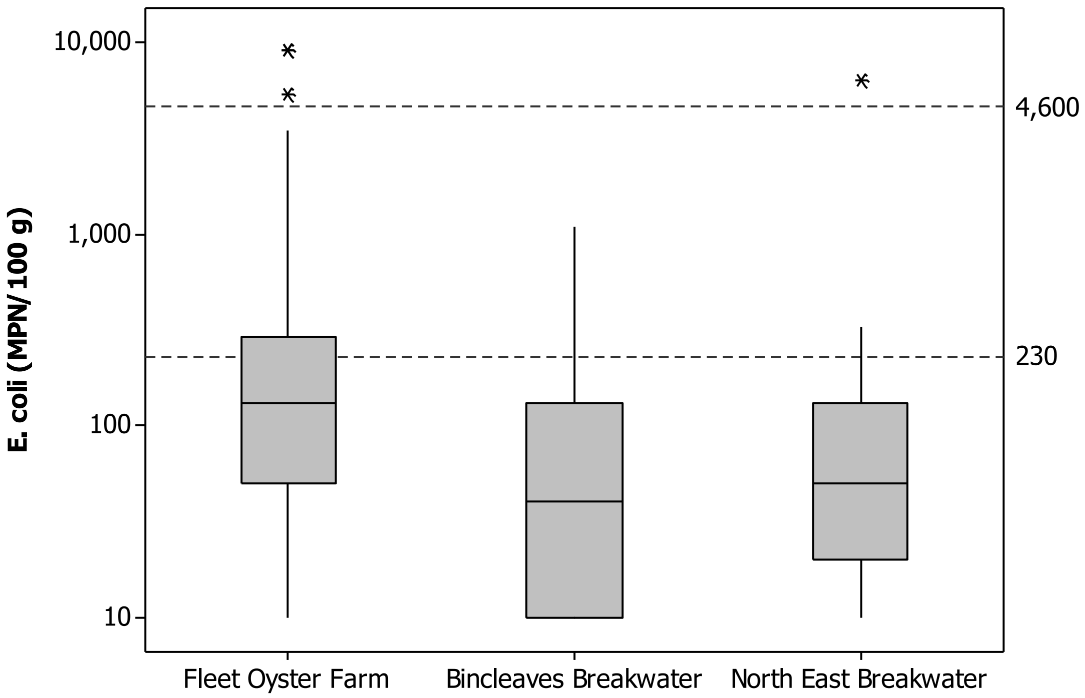


Figure XI.3: Boxplots of *E. coli* results from Pacific oyster RMPs from 2003 onwards.

Figure XI.4 Boxplot of E. coli results from the scallop RMP from 2003 onwards.

Statistical comparisons (One-way ANOVA) of mussel RMPs showed that there were no significant differences between sites ($p = 0.291$). Similar comparisons for Pacific oyster RMPs revealed significant differences ($p < 0.001$). Post ANOVA Tukey tests showed that the *E. coli* results at Fleet Oyster Farm were significantly higher than at the other RMPs, and North East Breakwater had higher results than Bincleaves Breakwater.

XI.2. Overall temporal pattern in results

Figure XI.5, Figure XI.6 and Figure XI.7 show the overall temporal patterns in *E. coli* levels in mussels, Pacific oysters and scallops respectively.

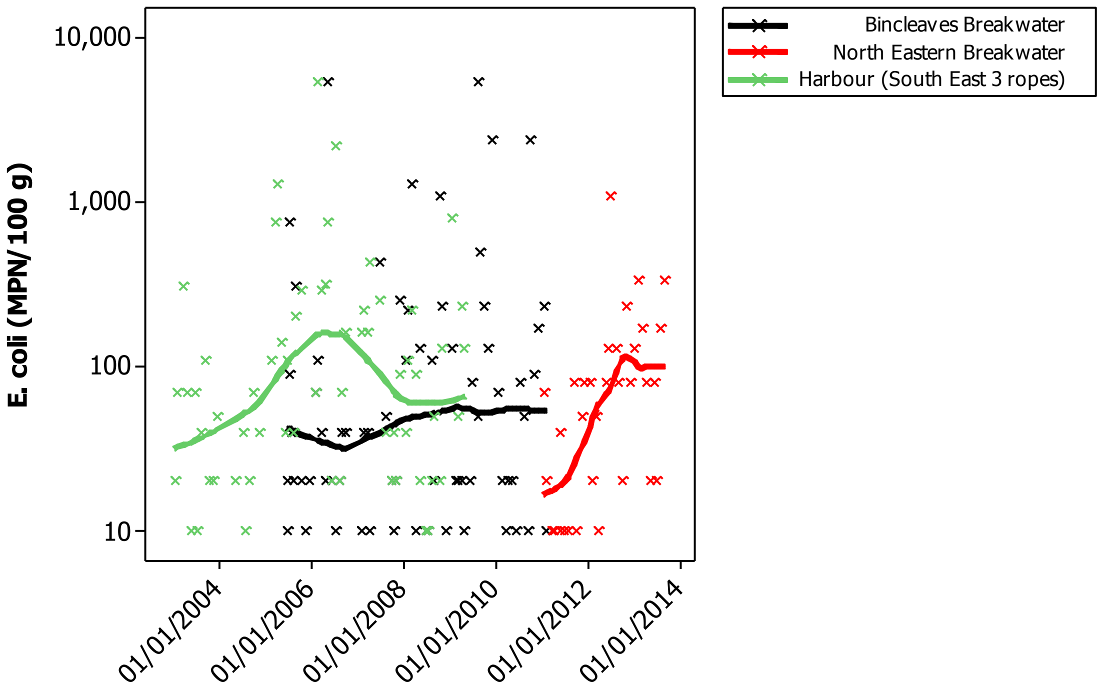


Figure XI.5: Scatterplot of *E. coli* results for mussels overlaid with loess lines.

At the mussels RMPs *E. coli* levels at Bincleaves Breakwater remained relatively stable for the entire period of sampling from 2005 to 2011. At Harbour (South east 3 ropes), *E. coli* levels rose sharply from 2005 before peaking in 2006 almost an order of magnitude higher than 2003 levels. *E. coli* levels then declined again to levels similar to 2003 before sampling ceased in 2009. At North Eastern Breakwater, *E. coli* levels appear to have increased greatly since the start of sampling in 2011. However, not enough data are yet available to determine whether this is a true trend.

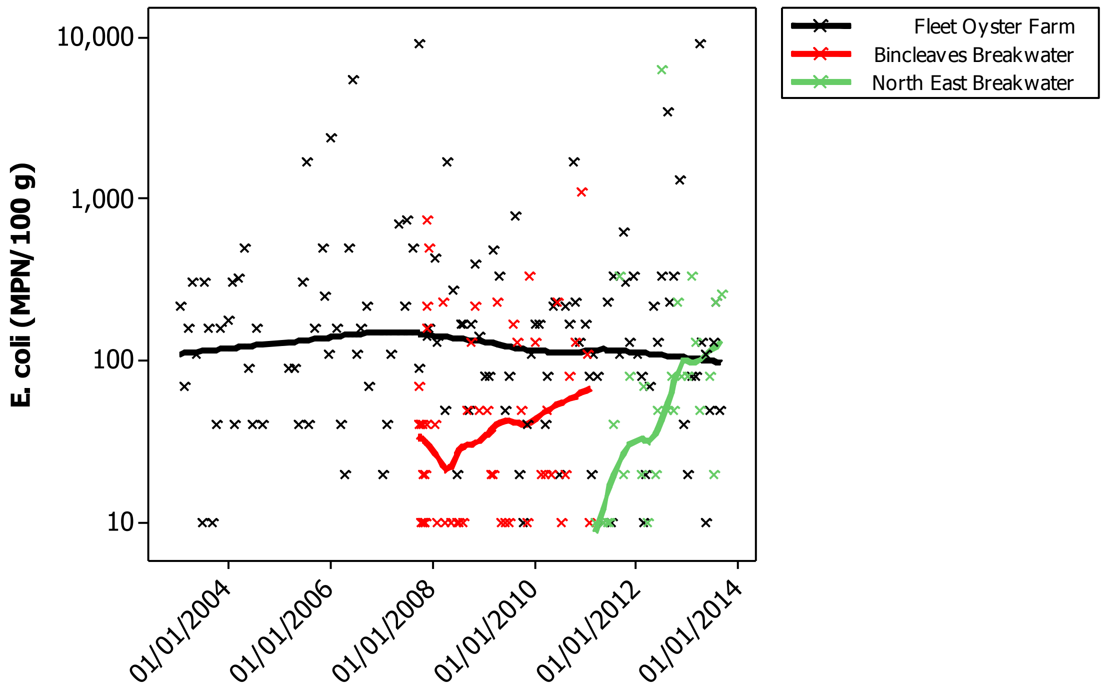


Figure XI.6: Scatterplot of *E. coli* results for Pacific oysters with loess lines.

E. coli levels at the Fleet Oyster Farm RMP a have remained stable from 2003 to present. At Bincleaves Breakwater, *E. coli* levels increased slightly from the start of sampling in 2007 until the cessation of sampling in 2011. At north East Breakwater, while *E. coli* levels there appears to have been a dramatic increase in *E. coli* levels since the initiation of sampling in 2011, it is likely that this trend is skewed by the initial very low results and a single high result in July 2012. It is therefore not possible to say with any degree of certainty whether there has been a trend of increasing *E. coli* levels.

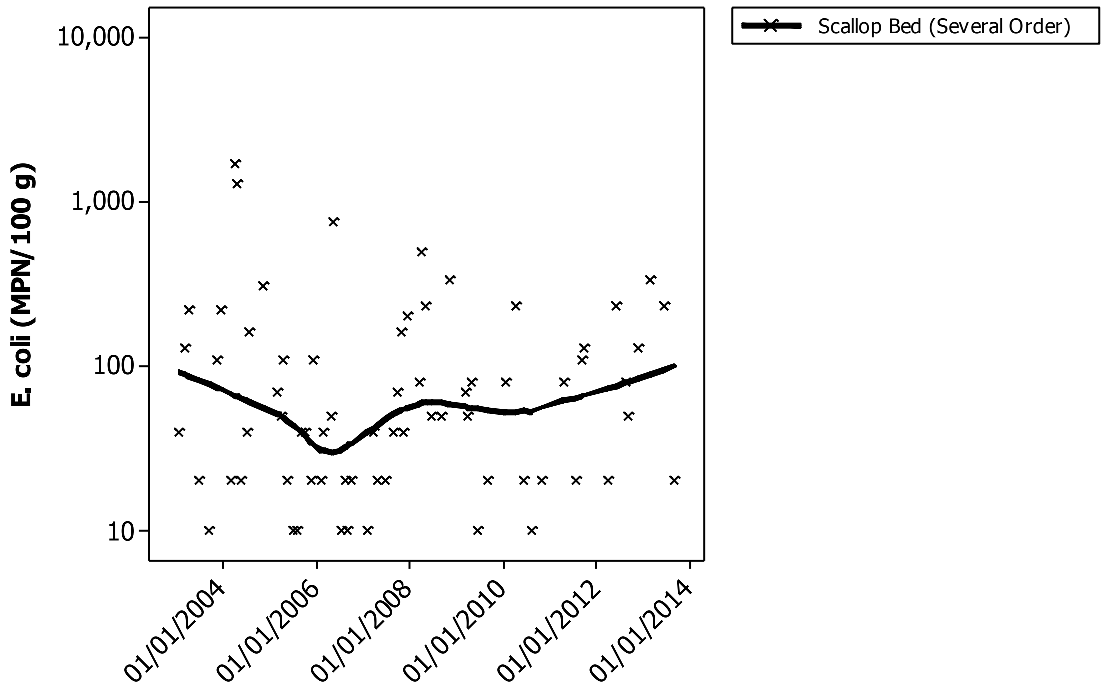


Figure XI.7: Scatterplot of *E. coli* results for scallops overlaid with loess lines.

At the Scallop Bed RMP, *E. coli* levels have remained relatively stable since 2003, with a slight decrease in 2006.

XI.3. Seasonal patterns of results

Figure XI.8, Figure XI.9 and Figure XI.10 show the seasonal patterns in *E. coli* levels at mussel, Pacific oyster and scallop RMPs respectively.

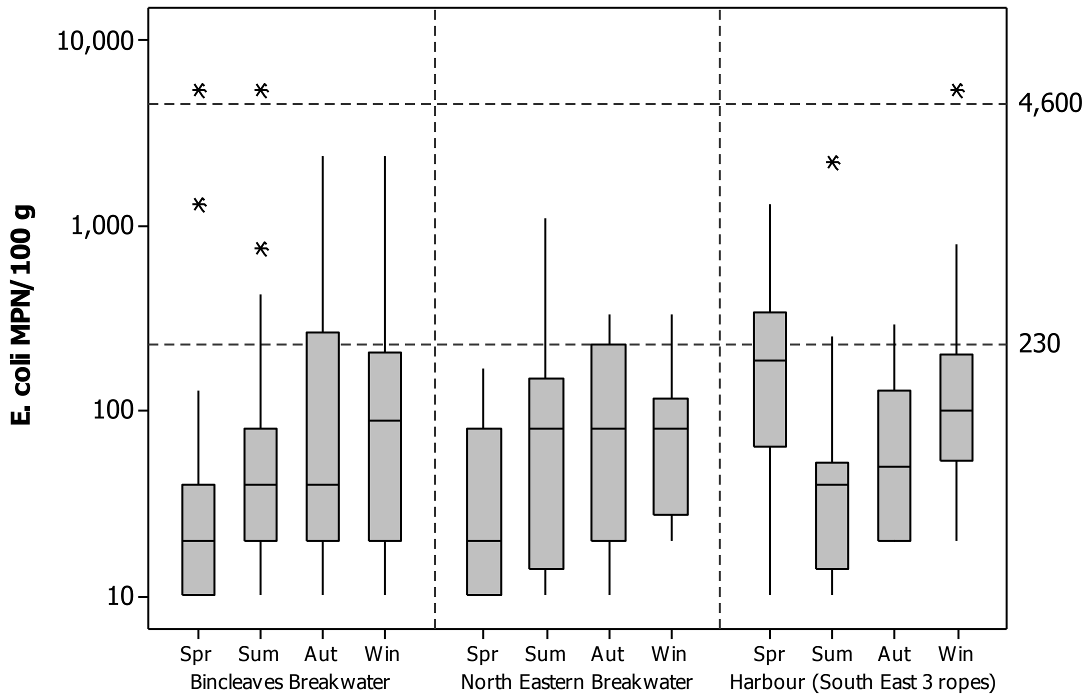


Figure XI.8: Boxplot of *E. coli* results in mussels by RMP and season.

One-way ANOVA tests revealed that there were no significant differences in *E. coli* levels between seasons at Bincleaves Breakwater (p = 0.61) or North Eastern Breakwater (p = 0.371)mussel RMPs. However there was a significant difference between seasons at Harbour (south East 3 ropes) (p = 0.008). Post ANOVA Tukey tests showed that E. coli levels were significantly higher in spring than in summer at this site.

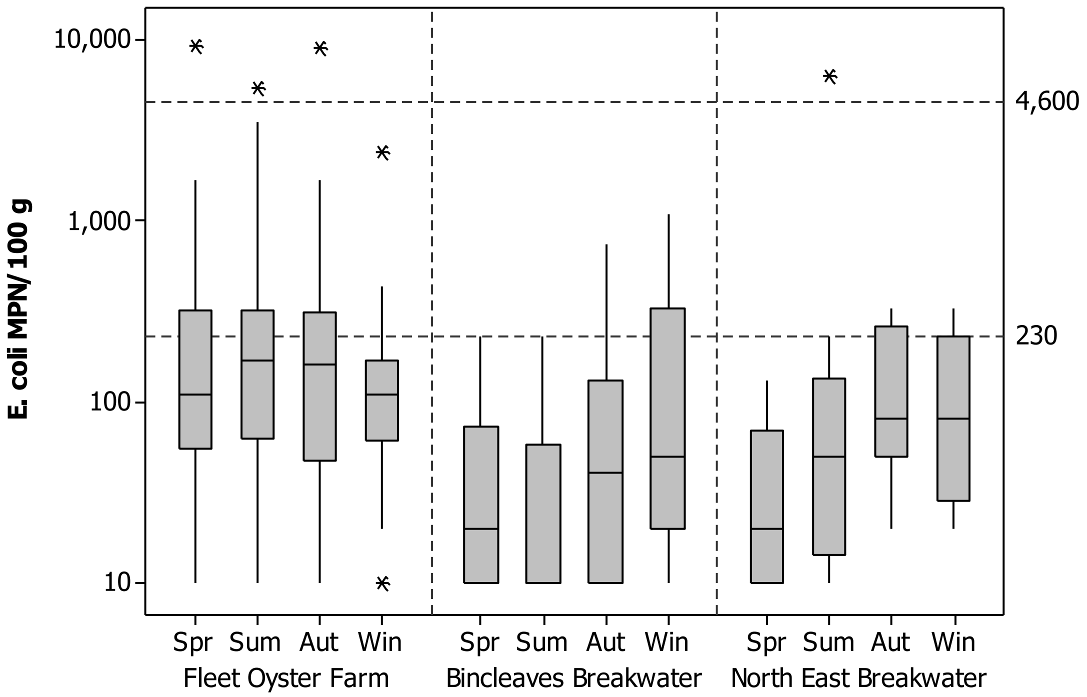


Figure XI.9: Boxplot of *E. coli* results in Pacific oysters by RMP and season.

One-way ANOVA tests revealed no significant differences between seasons at any of the Pacific Oyster RMPs. The seasonal pattern of results does appear to differ between the Fleet and the two locations in Portland Harbour.

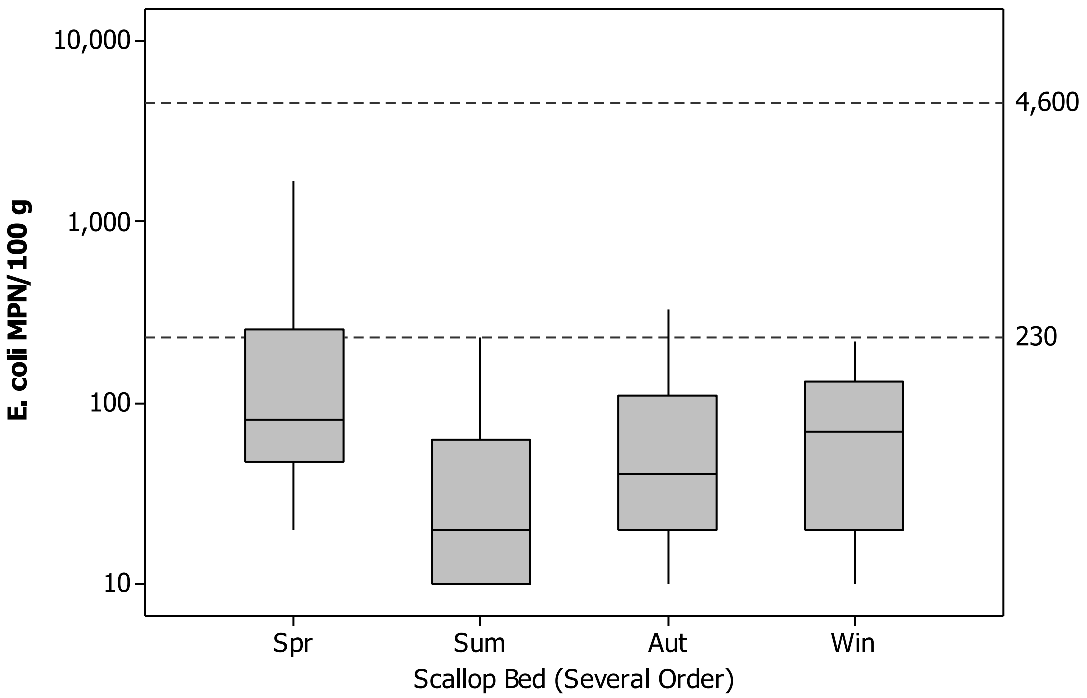


Figure XI.10: Boxplot of *E. coli* results in scallops by RMP and season.

One-way ANOVA tests showed that there was a significant difference between seasons at the Scallop Bed RMP. Post ANOVA Tukey tests showed that levels of *E. coli* were higher in spring than in summer.

XI.4. Influence of tide

To investigate the effects of tidal state on *E. coli* results, circular-linear correlations were carried out against the high/low and spring/neap tidal cycles for each RMP where more than 30 samples had been taken. Results of these correlations are summarised in Table XI.2, and significant results are highlighted in yellow.

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

		High/low tides		Spring/neap tides	
Site Name	**Species**	**r**	**p**	**r**	**p**
Bincleaves Breakwater	Mussel	0.044	0.875	0.102	0.495
North Eastern Breakwater	Mussel	0.164	0.447	0.368	0.017
Harbour (South East 3 ropes)	Mussel	0.336	0.001	0.343	0.001
Fleet Oyster Farm	Pacific oyster	0.136	0.104	0.194	0.010
Bincleaves Breakwater	Pacific oyster	0.141	0.362	0.277	0.020
Scallop Bed (Several Order)	Scallops	0.017	0.981	0.059	0.794

Figure XI.11 presents a polar plot of $\log_{10}$ *E. coli* results against tidal states on the high/low cycle for Harbour (South East 3 ropes). High water at Portland 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.

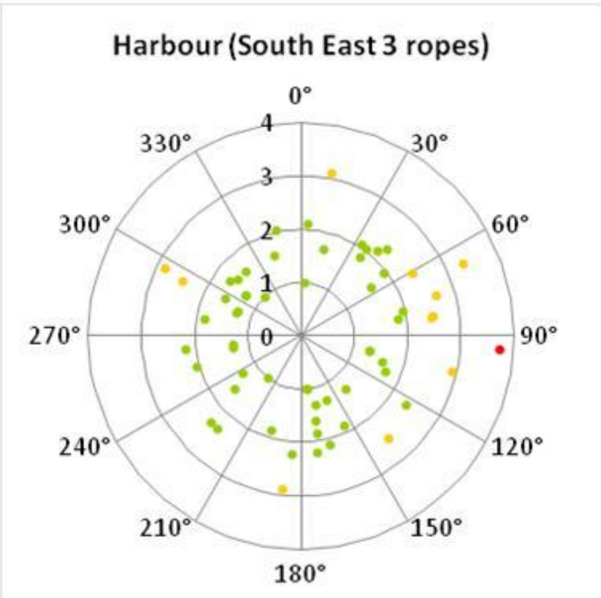


Figure XI.11: Polar plot of $\log_{10}$ *E. coli* results (MPN/100g) at Harbour (South East 3 ropes) mussel RMP against high/low tidal state

Higher *E. coli* levels tended to occur whilst the tide was ebbing at the Harbour (South East 3 ropes) mussel RMP. This suggests that water flooding into the harbour is cleaner than that ebbing from it. Figure XI.12 presents polar plots of log_{10} *E. coli* results against the spring / neap tidal cycle for each mussel RMP where a significant correlation was detected. 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.

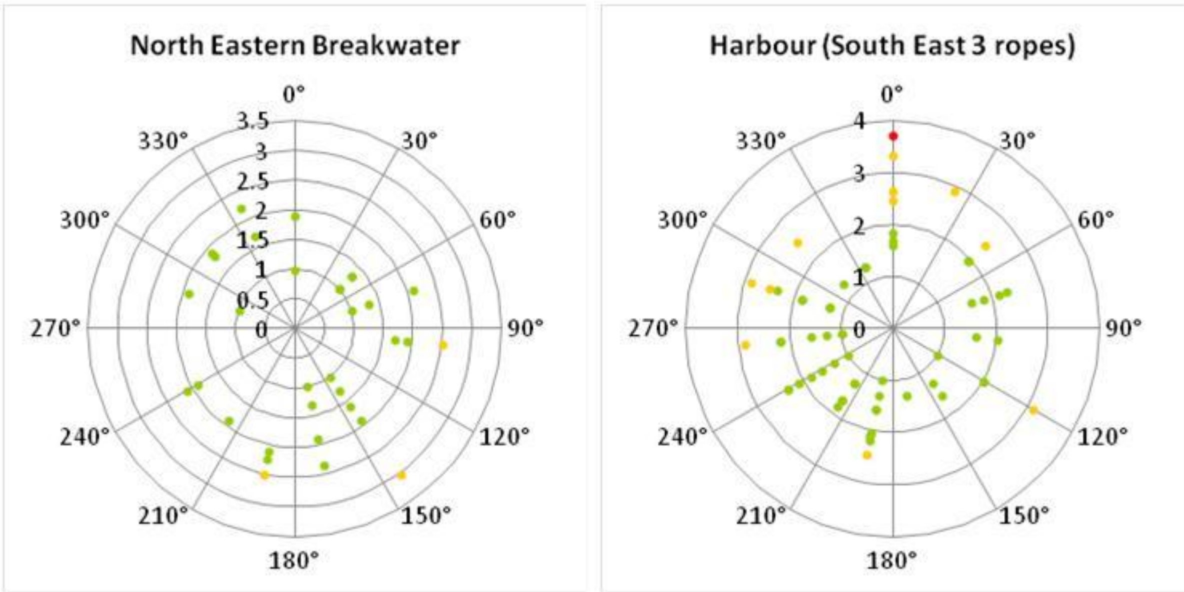


Figure XI.12: Polar plots of log_{10} *E. coli* results (MPN/100g) at mussel RMPs against spring/neap tidal state

At north Eastern Breakwater, *E. coli* levels tended to occur a few days around neap tides, whereas at Harbour (South East 3 ropes), higher results tended to occur towards spring tides.

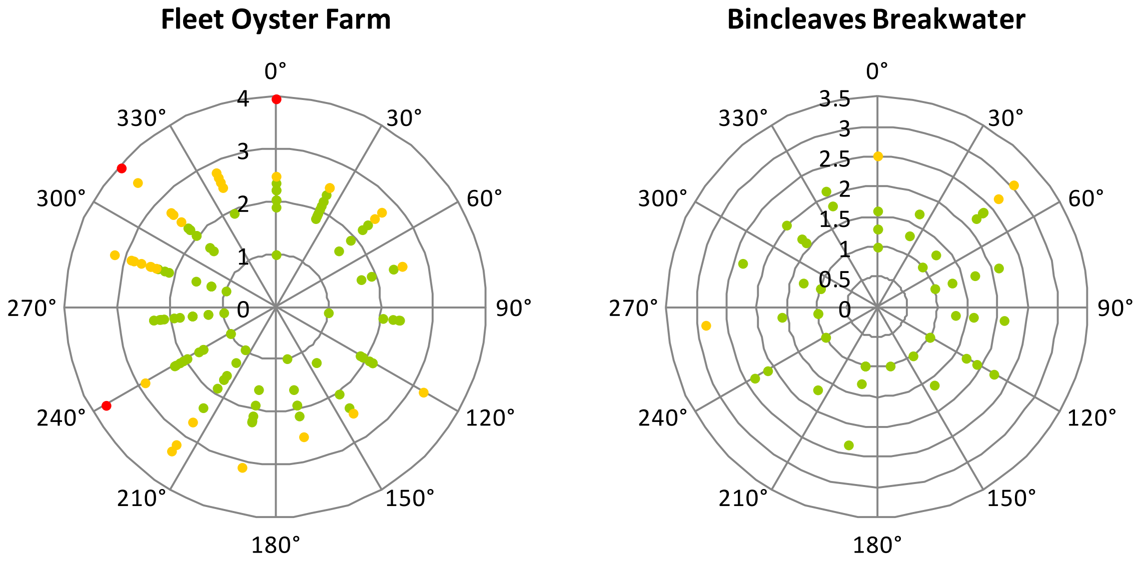


Figure XI.13: Polar plot of log10 *E. coli* results (MPN/100g) at Pacific oyster RMPs against spring/neap tidal state

At Fleet Oyster Farm, there were fewer low results recorded during spring tides. At Bincleaves Breakwater, no strong patterns are apparent.

XI.5. Influence of rainfall

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

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

	Site	Bincleaves Breakwater	North Eastern Breakwater	Harbour (South East 3 ropes)	Fleet Oyster Farm	Bincleaves Breakwater	North East Breakwater	Scallop Bed (Several Order)
	Species	Mussel			Pacific oyster			Scallops
	n	71	24	62	114	48	19	66
24 hour periods prior to sampling	1 day	0.111	0.392	0.149	0.130	-0.048	0.460	0.127
	2 days	0.169	0.558	0.328	0.200	0.172	0.432	0.091
	3 days	0.249	0.575	0.053	0.069	0.159	0.588	0.093
	4 days	0.130	0.047	0.276	-0.108	0.120	0.064	0.006
	5 days	0.329	0.068	0.092	-0.083	0.194	-0.050	0.339
	6 days	0.055	0.451	0.064	0.109	0.154	0.553	-0.008
	7 days	0.127	0.516	0.047	0.047	0.197	0.520	0.033
Total prior to sampling over	2 days	0.192	0.588	0.278	0.228	0.127	0.540	0.105
	3 days	0.281	0.674	0.200	0.182	0.207	0.660	0.118
	4 days	0.315	0.554	0.225	0.130	0.247	0.527	0.134
	5 days	0.364	0.574	0.215	0.076	0.284	0.541	0.214
	6 days	0.335	0.652	0.150	0.080	0.329	0.604	0.194
	7 days	0.340	0.670	0.109	0.087	0.343	0.582	0.225

Rainfall rapidly had a significant impact on *E. coli* levels in both mussels and oysters at North Eastern Breakwater. However at all other sites, it took at least two days until rainfall impacted *E. coli* levels. The influence of rainfall at Fleet Oyster Farm was rapid but weak.

XI.6. Bacteriological survey

A bacteriological survey was undertaken in this area, during which bagged oysters were deployed at three locations on the 8th October 2013. These bags were allowed to equilibrate then sampled and tested for *E. coli* in oyster flesh on three occasions.

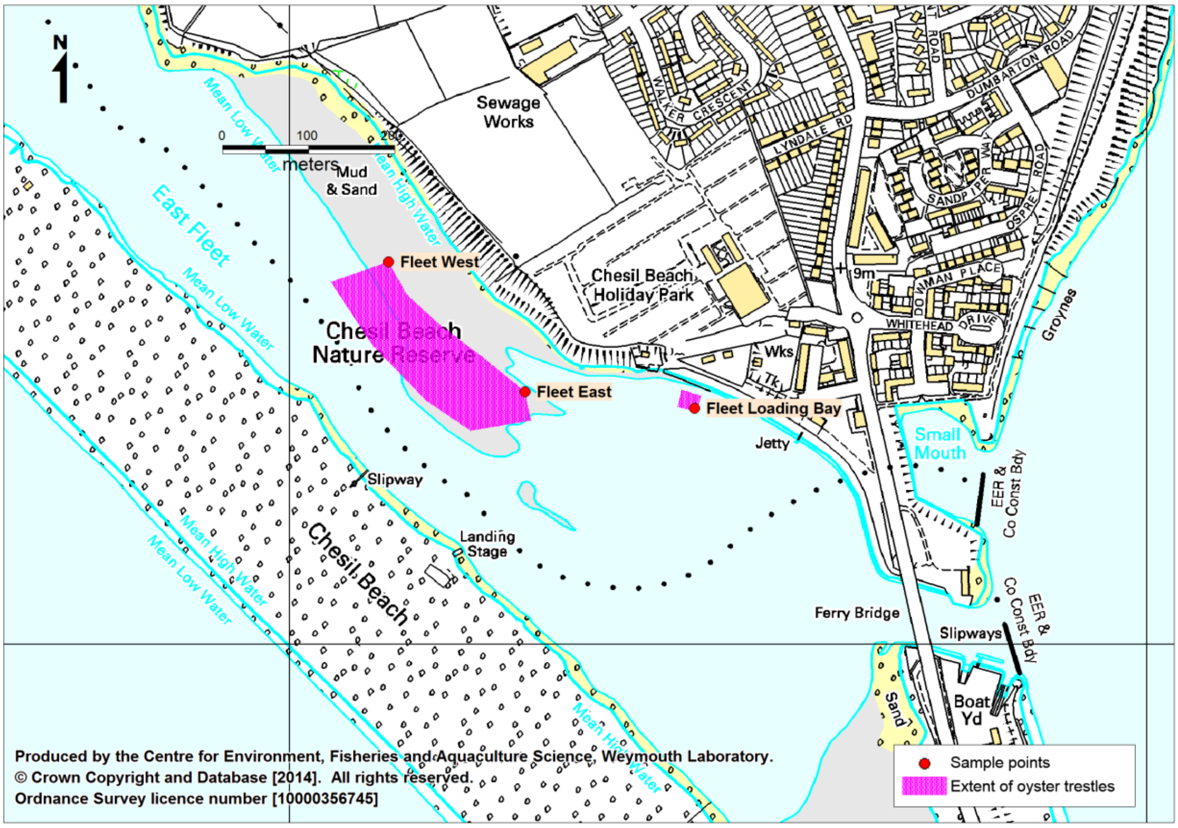


Figure XI.14: Bacteriological survey points

Table XI.4: Bacteriological survey results (*E. coli* MPN/100g in Pacific oysters)

Site	Fleet West	Fleet East	Fleet Loading Bay
NGR	SY 6611 7645	SY 6627 7627	SY 6647 7627
05/11/2013	330	490	490
04/12/2013	490	1300	5400
23/01/2014	330	790	2200
Geometric mean	376	795	1799

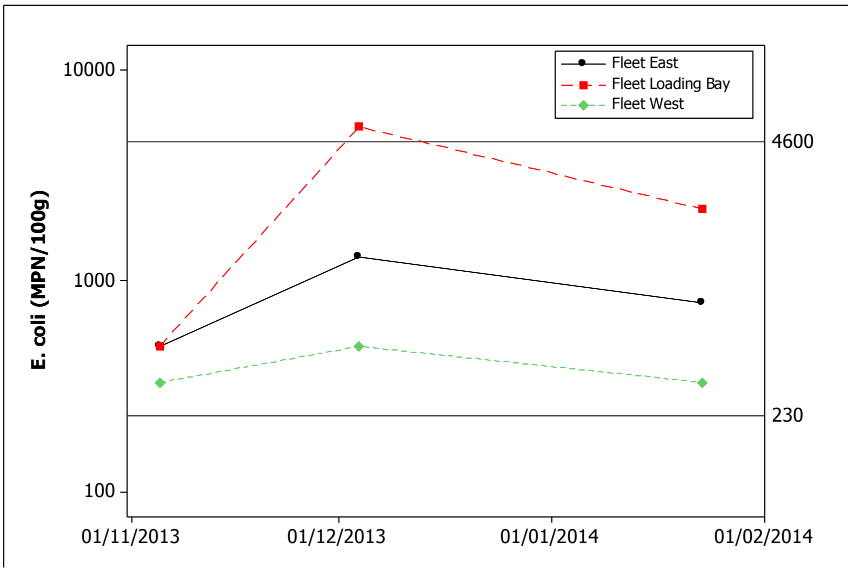


Figure XI.15: Scatterplot of *E. coli* results against date

These limited results show that results were noticeably higher towards the eastern end of the site. This suggests that there is a source of contamination to the east of the site which is the main contaminating influence, and that the existing RMP at the loading bay should be retained. It should however be noted that these results may not be representative of the situation at other times of the year due to potential changes in sources of pollution.

Appendix XII. Shoreline Survey Report

Date (time):

3rd October 2013 (10:00-13:00)

Cefas Officers:

Alastair Cook and Fiona Vogt

Local Enforcement Authority Officers:

None present

Area surveyed:

North shore of The Fleet from Ferrybridge to The Narrows (Figure XII.1).

Weather:

3rd October 2013, rain, wind SE 15 km/h, air temp 16.2°C.

Tidal Predictions:

Admiralty Totaltide predictions for Portland (50°32'N 2°26'W). All times in this report are BST. Predicted heights are in metres above Chart Datum

03/10/2013		
High	06:20	1.8 m
Low	11:21	0.4 m
High	18:32	2.0 m
Low	23:41	0.2 m

XII.1. Objectives:

The shoreline survey aims to obtain samples of freshwater inputs to the area for bacteriological testing; confirm the location of previously identified sources of potential contamination; locate other potential sources of contamination that were previously unknown and find out more information about the fishery. A full list of recorded observations is presented in Table XII.1 and the locations of these observations are mapped in Figure XII.1. Photographs are presented in Figure XII.3 to Figure XII.17. The shoreline survey was undertaken on foot.

XII.2. Description of Fishery

Pacific oyster harvesting from an oyster trestle farm occurs within the Fleet survey area. They are grown from seed on the trestles, taking between two and three years to reach maturity. There is one main block of trestles, and a smaller, more accessible pre harvest holding area. Harvesting is by hand, and there are purification tanks on site. No conservation controls apply to cultured Pacific oysters and harvesting may be at any time of the year, although the cafe where the oysters are mainly sold shuts for a couple of months during the winter. There are no plans to extend the farm in the future.

There are also some wild shellfish in the fleet, including clams and cockles, but there are insufficient stocks to classify these species. The site manager indicated he had no interest in harvesting any of the naturally occurring shellfish stocks in the area, although some casual gathering occurs from time to time.

Sources of contamination

Sewage discharges

There is only one water company discharge within the survey area, Ferrybridge PS. Three pipes possibly associated with this pumping station were seen (observation 13 and 14). There was no flow from these pipes at the time of the survey. There is a discharge from the cafe and oyster shed (observation 11). Food processing debris were seen at the end of this pipe. The site manager confirmed that there is no sewage content from this discharge, just water used in the purification tanks and also for food preparation. There are two other small private discharges located near Ferrybridge, but these would not be evident on a survey as they discharge to soakaway. A large cast iron pipe was recorded passing through the trestles (observation 7) but this is an old pipe which has been redundant for many years.

Freshwater inputs

One minor stream was found, discharging to the head of a small embayment just west of the oyster farm (observations 2 and 3). This stream was measured (2 channels) and sampled for *E. coli*. The result for the water sample taken from this stream contained relatively high levels of *E. coli* (9000 cfu/100ml). This indicates some faecal contamination, possibly from agricultural sources.

Boats and Shipping

Several small boats were seen moored on the Chesil Beach side of the Fleet but none appeared large enough to have on board toilets.

Livestock

The only livestock observed were two horses in fields above the area surveyed (observation 9).

Wildlife

Some (<10) birds were seen resting on the trestles (observation 10).

Figure XII.1: Locations of Shoreline Observations (see Table XII.1 for details)

Table XII.1: Details of Shoreline Observations

Obs No.	Position	Observation	Figure	Sample
1	SY6526577159	Sea water sample.		Fleet 1
2	SY6574476969	Stream across beach, 30cm wide x 2 cm deep x 0.05 m/s.	Figure XII.3 & Figure XII.4	Fleet 2
3	SY6574476968	Stream across beach, 20cm wide x 1cm deep x 0.097 m/s. Freshwater sample	Figure XII.5	Fleet 3
4	SY6577276957	Sea water sample.		Fleet 4
5	SY6578376903	Sea water sample and sediment sample.		Fleet 5 & Sed* A
6	SY6582576803	Wooden huts near shore	Figure XII.6	
7	SY6611276566	Cast iron pipe across foreshore, 30cm diameter. Not flowing.	Figure XII.9,Figure XII.11,Figure XII.12	
8	SY6612276557	Wooden huts near the trestles	Figure XII.7	
9	SY6612276557	2 horses in fields above the shore	Figure XII.8	
10	SY6624176402	Birds resting on trestles	Figure XII.10	
11	SY6626476403	Concrete pipe with carrots, fish scales and fish bones located at its outlet. Narrow green plastic pipe also across shore, 5 cm diameter. Sewage odour. Sediment sample.	Figure XII.13 Figure XII.14	Sed B
12	SY6643876330	Concrete pipe, 35cm diameter. Covered by tide so not sure if it was flowing	Figure XII.15	
13	SY6650976299	Ferrybridge PS outfall pipe	Figure XII.16	
14	SY6659976277	Another outfall pipe, presumed also Ferrybridge PS		
15	SY6660776266	Oyster sample bag		
16	SY6663776238	Concrete structure underwater- possibly pipe. Sea water sample.	Figure XII.17	Fleet 6

*Sediment sample

Sample Results

Sea water and freshwater, and sediment samples were taken to give estimates of *E. coli* (CFU/100ml) loadings (Table XII.2 and Figure XII.2). The shoreline survey was undertaken in very wet conditions so stream discharge volumes and levels of *E. coli* in water samples are likely to be considerably higher than may be anticipated during more normal conditions.

Table XII.2: Water sample *E. coli* results, spot flow gauging results and estimated stream loadings

Observation No	Sample	*E. coli* concentration (CFU/100 ml)	Discharge (m^3/day)	*E. coli* loading (CFU/day)*
1	Fleet 1	150	-	-
2&3	Fleet 3	9000	42.7	3.8×10^9
4	Fleet 4	20	-	-
5	Fleet 5	160	-	-
16	Fleet 6	130	-	-
5	Sediment A	50	-	-
11	Sediment B	1.1×10^3	-	-

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

Levels of *E. coli* in the sea water samples ranged from 20-160 cfu/100ml. The sample taken from the freshwater stream (Fleet 3, observation 3) had a high bacterial concentration (9000cfu/100ml). Sediment sample A, taken near the shoreline where the stream enters the sea, contained 50cfu/100ml and sediment B contained 1100cfu/100ml. This latter sample was taken near the outlet of the purification unit outfall.

Figure XII.2: Locations of water and sediment samples taken from the Fleet

Figure XII.3

Figure XII.4

Figure XII.5

Figure XII.6

Figure XII.7

Figure XII.8

Figure XII.9

Figure XII.10

Figure XII.11

Figure XII.12

Figure XII.13

Figure XII.14

Figure XII.15

Figure XII.16

Figure XII.17

References

BBC News, 2013. Available at: http://www.bbc.co.uk/news/uk-england-dorset-24460021. Accessed October 2013

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

Cefas, 2009. Sanitary Survey Report Portland Harbour – Dorset. Regulation (EC) No 854/2004. Classification of Bivalve mollusc production areas in England and Wales.

Crabhouse Cafe Website, 2013. Oyster Farm Information. Available at: http://www.crabhousecafe.co.uk/oyster-farm/oyster-farm-information/ Accessed August 2013

EC Regulation 854/2004. Classification of Bivalve Mollusc Production Area in England and Wales. Sanitary Survey Report. Portland Harbour – Dorset. CEFAS Weymouth

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

European Communities, 2004. EC Regulation No 854/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules on products of animal origin intended for human consumption. Official Journal of the European Communities L226: 83-127.

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

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

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

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

HR Wallingford (2007). Portland Harbour Improvements. Wave and Flow Modelling. Report EX5206.

Johnston, C.M. and Gilliland, P.M., 2000. Investigating and managing water quality in saline lagoons based on a case study of nutrients in the Chesil and the Fleet European Marine Site. English Nature (UK Marine SACs Project)

Jurassic Coast, 2012. Chesil & the Fleet: The Great Beach. Available at: http://jurassiccoast.org/find-out-about/141-explore-the-coast/361-chesil-aamp-the-fleet# Accessed August 2013

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

Langston, W.J.; Chesman, B.S.; Burt, G.R.; Hawkins, S.J.; Readman, J. and Worsfold, P., 2003. Chesil and the Fleet. (candidate) Special Area of Conservation Special Protection Area Marine Biological Association Occasional publication No.11

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

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

NERC, 2012. National River Flow Archive, Catchment Spatial Information. Available at: http://www.ceh.ac.uk/data/nrfa/data/search.html. Accessed September 2013.

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

Portland Port Authority, 2013. Available at: http://www.portland-port.co.uk/ Accessed August 2013

Robinson, I.S., 1983. A tidal flushing model of the Fleet - An English tidal lagoon, Estuarine, Coastal and Shelf Science, Volume 16, Issue 6, June 1983, Pages 669-688, ISSN 0272-7714, http://dx.doi.org/10.1016/0272-7714(83)90078-1.

SCOS, 2012. Scientific Advice on Matters Related to the Management of Seal Populations: 2012. Available at: http://www.smru.st-andrews.ac.uk/documents/1199.pdf Accessed July 2013.

The Green Blue, 2010. Pump Out Directory. Available at: http://www.thegreenblue.org.uk/pump_out_directory.aspx Accessed August 2013

The Portland Harbour Revision Order 1997. SI 1997/2949, HMSO London

Walmsley, S.A. and Pawson M.G. (2007). The Coastal Fisheries of England and Wales Part V: A Review of their Status, 2005-6. Science Series Technical Report Number 140. CEFAS Lowestoft.

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

List of Abbreviations

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

Glossary

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

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

Acknowledgements

The management at the Fleet Oyster Farm.