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

Alde Estuary

September 2014

Food Standards Agency

Cover photo: Aerial view of oyster lays in the Alde estuary

© Crown copyright 2014

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

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

Contacts

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

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

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

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

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

☎ +44 (0) 020 7276 8970
✉ shellfishharvesting@foodstandards.gsi.gov.uk

Statement of use

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

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 review	Fiona Vogt	21/08/2014
2	Draft for external review	Simon Kershaw	22/09/2014
Final	Final report post consultation	Simon Kershaw	10/12/2014

Consultation

Consultee	Date of consultation	Date of response
Suffolk Coastal Council	24/09/2013	16/10/2014
Eastern IFCA	24/09/2013	20/10/2014
Environment Agency	24/09/2013	21/10/2014
Anglian Water	24/09/2013	13/10/2014
Shellfish Association of Great Britain	24/09/2013	-
Natural England	24/09/2013	22/10/2014

Dissemination

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

Recommended Bibliographic Reference

Cefas, 2014. Sanitary survey of the Alde estuary. Cefas report on behalf of the Food Standards Agency, to demonstrate compliance with the requirements for classification of bivalve mollusc production areas in England and Wales under EC regulation No. 854/2004.

Contents

1. Introduction

1.1. Legislative Requirement

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

When consumed raw or lightly cooked, bivalves contaminated with pathogenic microorganisms may cause infectious diseases in humans (e.g. Norovirus-associated gastroenteritis, Hepatitis A and Salmonellosis). 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 anticipated 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 (*Crassostrea gigas*) and mussels (*Mytilus* spp.) within the Alde estuary. The area was prioritised for survey in 2014-15 by a shellfish hygiene risk ranking exercise of existing classified areas.

1.2. Area description

The survey area is situated on the east coast of England, in Suffolk and forms part of the Alde/Ore estuary complex, which discharges to the Southern North Sea (Figure I.1).

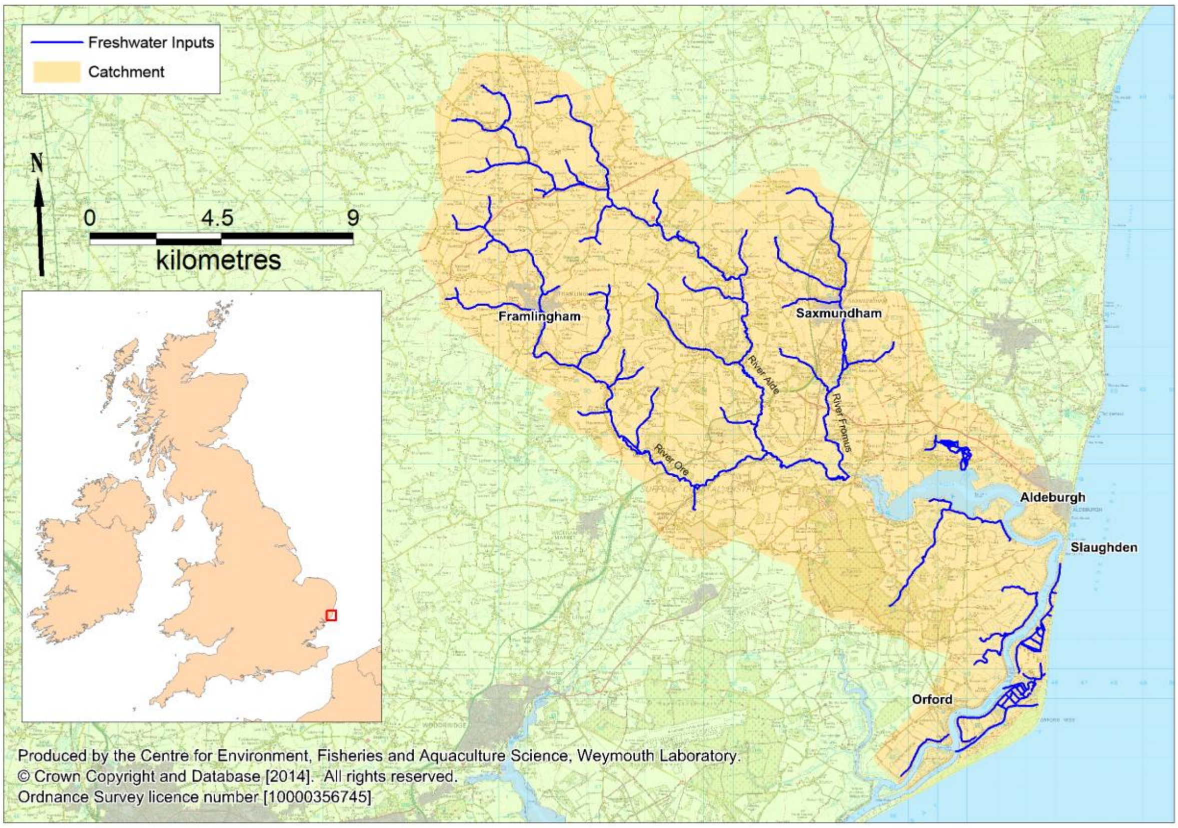


Figure I.1: Location of the Alde survey area

The Alde is a relatively long and narrow estuary that runs parallel to the coast behind a shingle bar for most of its length before heading inland and opening out into a wider, shallower tidal basin with more extensive intertidal areas. It is surrounded by low lying reclaimed land, which lies behind earth banks. There are two principal freshwater inputs, the River Alde/Ore and the River Fromus both of which discharge to the head of the estuary. It has a quiet, rural backdrop with only the small towns of Aldeburgh and Orford on its banks. It is used heavily by recreational yachts, with boating communities centred around Orford and Slaughden. The estuary has supported the current Pacific oyster culture fishery for several decades but at present it is not in production due to the ill health of the harvester. Naturally occurring mussel stocks were also exploited by the same harvester.

1.3. Catchment

Figure 1.2 illustrates landcover within the hydrological catchment of the Alde estuary upstream of the Butley confluence, as defined by local topography, which covers an area of 246 km². The catchment does not represent that of the whole of the Alde/Ore estuary complex as patterns of tidal circulation suggest that inputs to the Butley estuary and downstream of the Alde/Butley confluence will be of negligible significance to the fishery at Aldeburgh.

The catchment is rural in character, principally comprised of arable farmland with a large coniferous forest in its south west and significant areas of pasture adjacent to the shoreline. A small proportion of the catchment is urbanised, and with the main settlements at Framlington, Saxmundham, Aldeburgh and Orford.

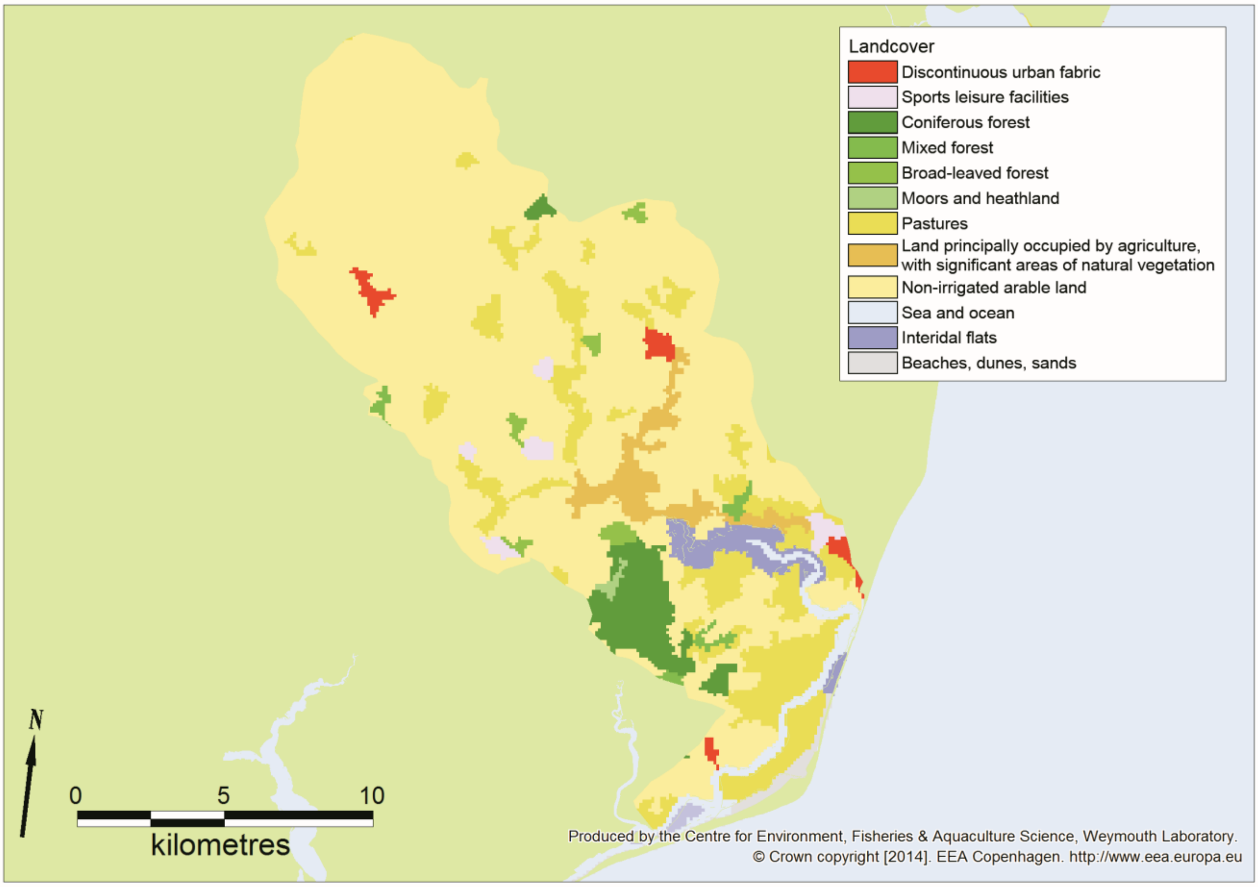


Figure 1.2: Landcover in the Alde survey area

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 catchment's underlying geology is predominantly clay and chalk overlain with boulder clay (NERC, 2012), therefore it comprises a moderate permeability and so there will be both groundwater and surface water flows.

2. Recommendations

Pacific oysters

Only one zone is required for Pacific oysters, which should encompass not only the existing site, but the entire lease area in case expansion occurs in the future. This area lies at the downstream end of a large area of yacht moorings. There is a small private sewage discharge to the Slaughden Quay area listed on the permit database, but it has not been possible to confirm if this is still in existence and if so where it is located exactly. The closest confirmed point source is a surface water outfall from the Aldeburgh Marshes, about 1.2 km upstream of the site. The main freshwater and sewage inputs enter the head of the estuary, which is about 10 km away so their impacts will be limited. Given the remoteness of the main sources, the lack of sources in close proximity to the shellfishery and the small size of the site, it is considered unlikely that there will be any noticeable variation in levels of contamination across it. Nevertheless, it is recommended that the RMP is located at the north east corner of the site to best capture contamination from up-estuary sources.

Mussels

Classification of mussels in the area will only be required should the Local Enforcement Authority (LEA) receive a request from a harvester, and are content that the harvester is entitled to exploit these stocks. Mussels are unlikely to be a continuous presence throughout this zone, and without any information on their distribution the zone boundaries represent the maximum extent of the area formerly classified for this species. This zone will be influenced by the same sources as described for the oyster farm, but the zone is much larger, extending through the area of moorings to about 7.5 km from the head of the estuary. The surface water outfall from the Aldeburgh Marshes discharges directly to this zone. It is therefore recommended that the RMP is located adjacent to this outfall. Should the recommended RMP location not coincide with a naturally occurring mussel bed then bagged mussels may be used instead, provided they are allowed to equilibrate *in situ* for at least two weeks prior to sampling. Sampling should be monthly and on a year round basis, and sampled stock should be of a market size (>50 mm).

3. Sampling Plan

3.1. General Information

Location Reference

Production Area	Alde
Cefas Main Site Reference	M008
Ordnance survey 1:25,000 map	Explorer 212
Admiralty Chart	2695

Shellfishery

Species/culture	Pacific oysters Mussels	Suspended bags Wild
Seasonality of harvest	No closed season	

Local Enforcement Authority

Name & Address	Suffolk Coastal District Council Council Offices Melton Hill Woodbridge Suffolk IP12 1AU
Environmental Health Officer	V Johnston
Telephone number	01394 444 629
E-mail	v.johnston@suffolkcoastal.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, 2014) indicates that sanitary assessments should be fully reviewed every 6 years, so this assessment is due a formal review in 2020. 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

Classification zone	RMP	RMP name	NGR	Latitude & Longitude (WGS84)	Species	Growing method	Harvesting technique	Sampling method	Tolerance	Frequency	Comments
Home Reach	B008I	Home Reach North	TM 4607 5465	52° 08.119' N 01° 35.658' E	Pacific oysters	Suspended net bags	Hand	Hand	10 m	Quarterly until reclassification is required, monthly thereafter.	Currently temporarily declassified. Will only require reclassification when the site has been restocked and stock is approaching a harvestable size.
Home Reach and Westrow Reach	B008J	Aldeburgh Marsh Outfall	TM 4590 5567	52° 08.672' N 01° 35.553' E	Mussels	Wild	Unknown	Hand	10 m	Monthly	Only required if classification is specifically requested. If this RMP coincides with a mussel bed, then wild stocks can be sampled. If it does not, then bagged mussels will have to be used.

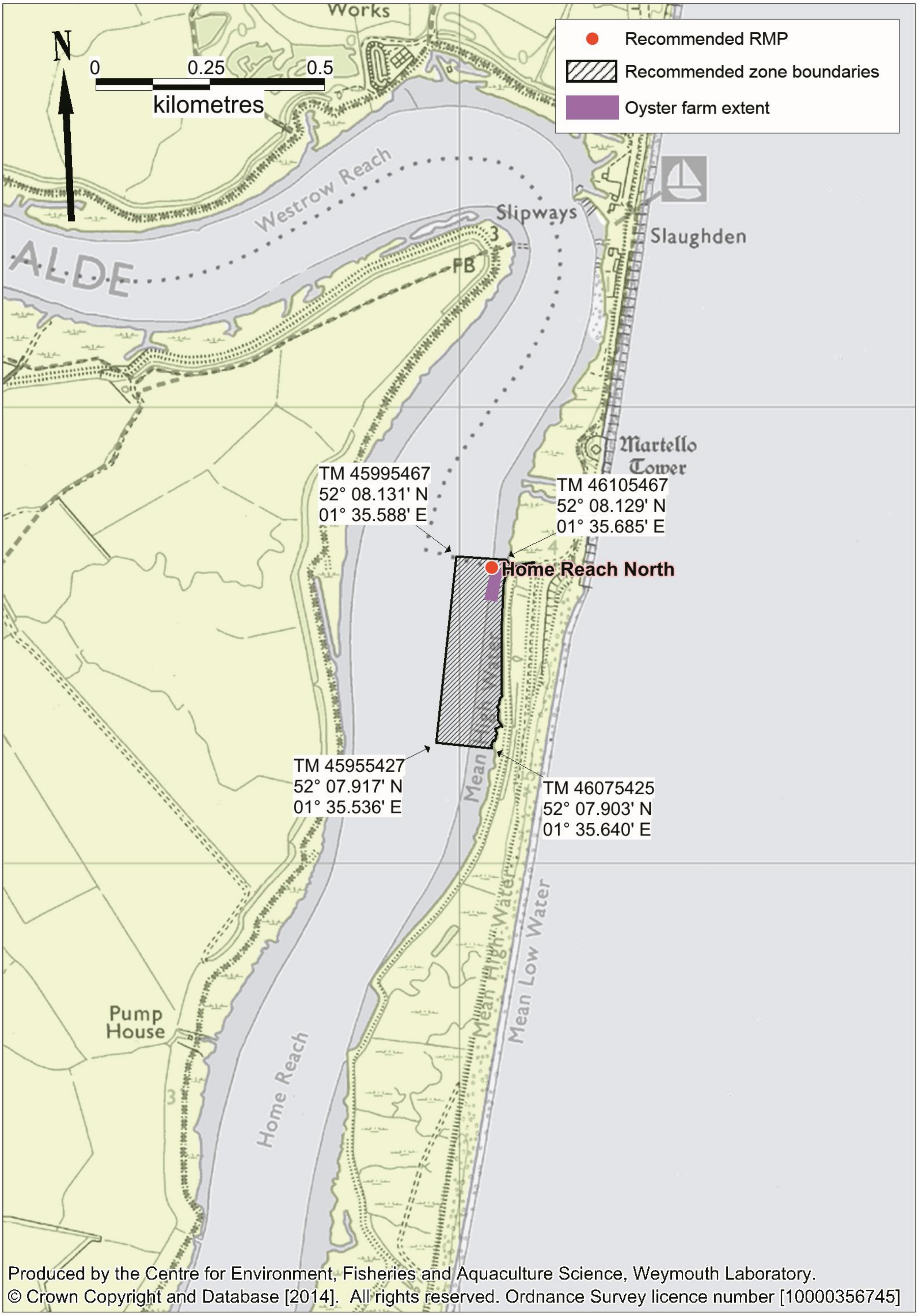


Figure 3.1: Recommended zoning and monitoring arrangements (Pacific oysters)

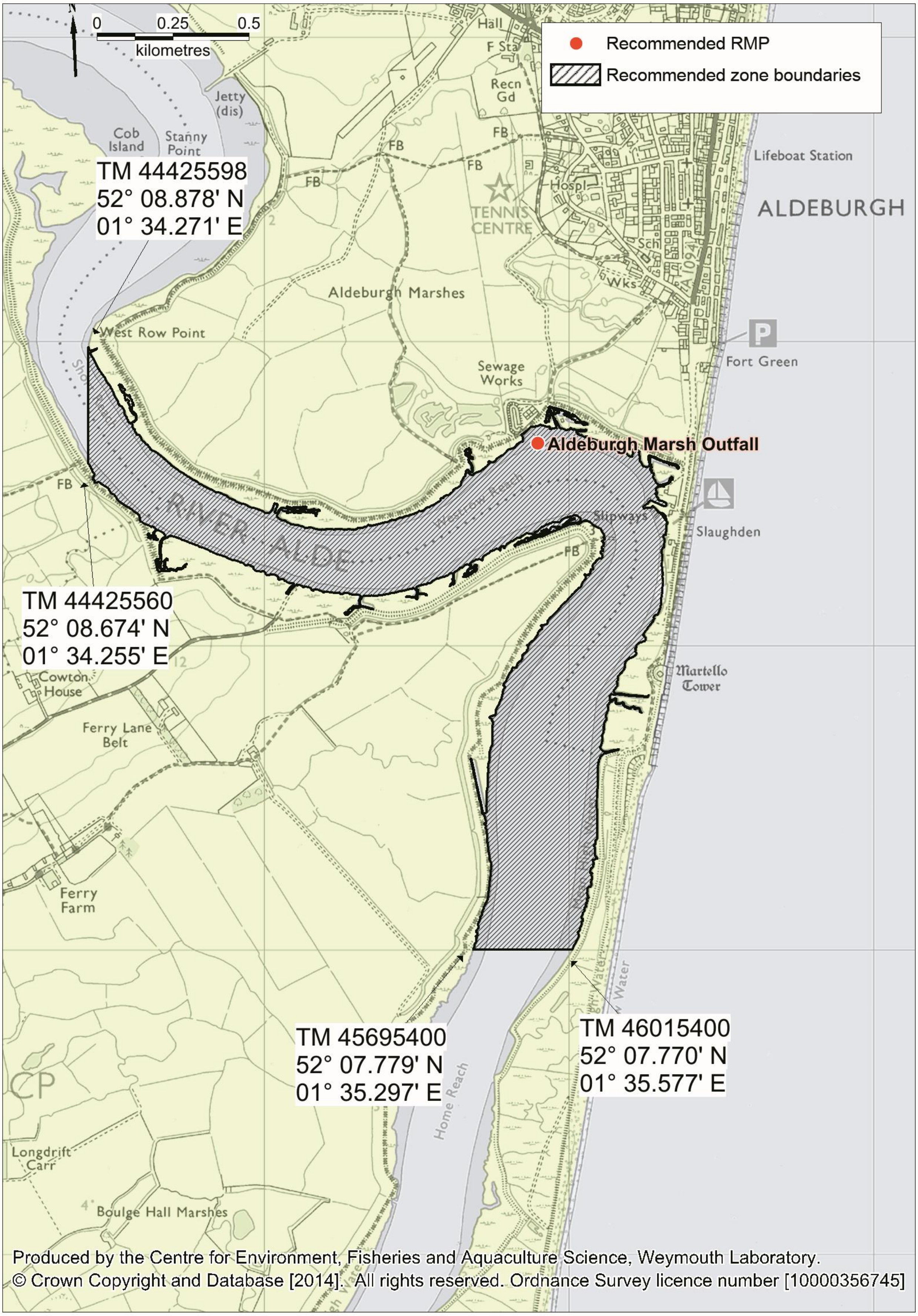
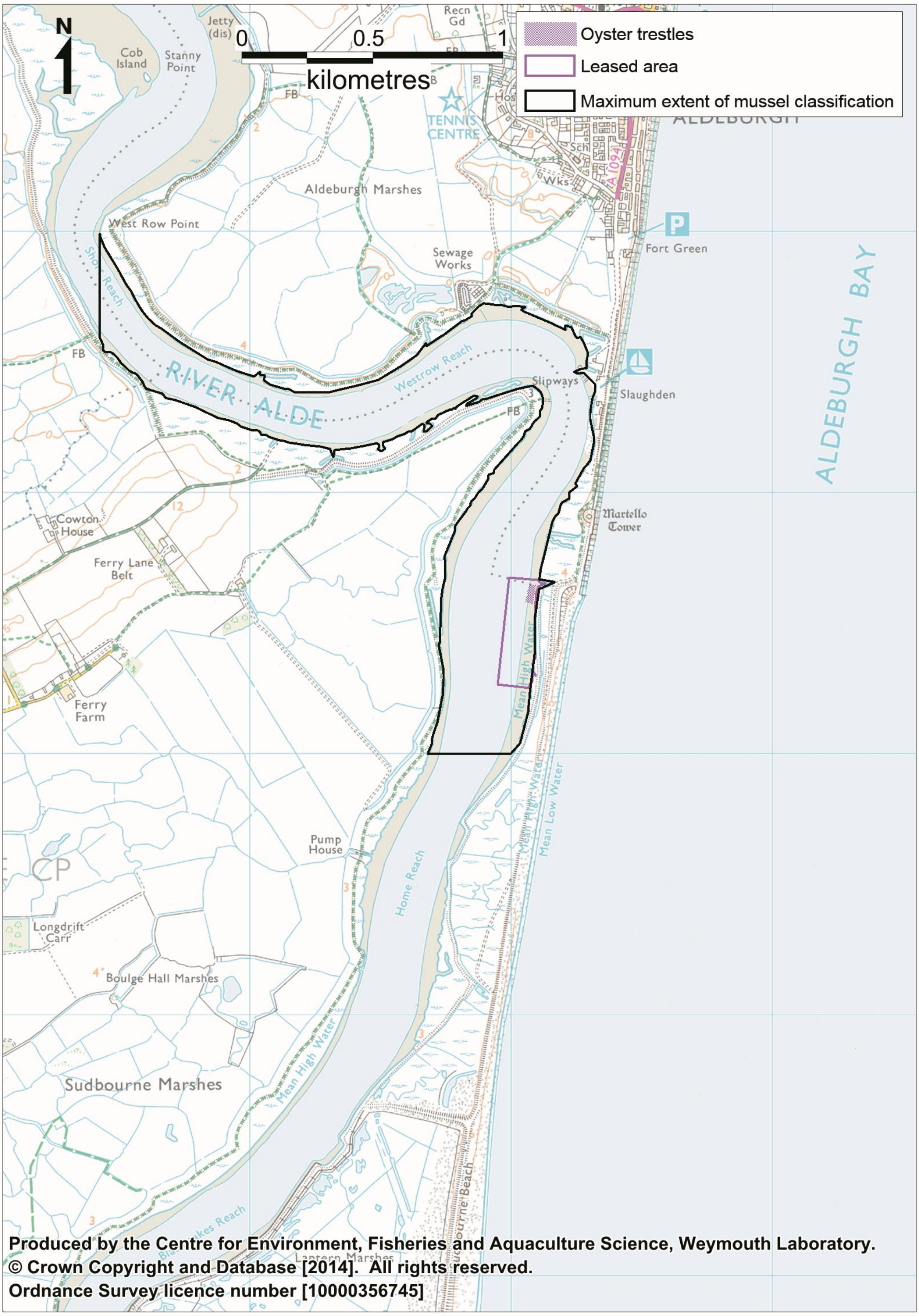


Figure 3.2: Recommended zoning and monitoring arrangements (mussels)

Figure 3.3: Location of current and recommended RMPs (Pacific oysters)

4. Shellfisheries

4.1. Description of fisheries



Produced by the Centre for Environment, Fisheries and Aquaculture Science, Weymouth Laboratory.
© Crown Copyright and Database [2014]. All rights reserved.
Ordnance Survey licence number [10000356745]

Figure 4.1: Location of oyster farm and extent of former mussel classification

The Pacific oyster fishery occupies a small proportion of the leased area, so therefore has significant potential for expansion. It has not been active for about two years due to ill health of the harvester. Formerly, relatively small volumes of Pacific oysters were ongrown from seed to a market size in mesh bags hung between wooden posts and sold to local markets. A minimal amount of mature stock remains on site, which is held there for sampling purposes. Although the harvester has expressed an interest in restocking the site, future prospects are uncertain. The fishery is not subject to any conservation controls and harvest may occur at any time of the year.

There are also some naturally occurring mussel beds at various locations between the oyster farm and West Row Point. The exact locations of these are uncertain, and the IFCA advise that they have not been subject to a stock survey. The maximum extent of the formerly classified area is shown in Figure 4.1. It is uncertain whether this was a private or a public fishery. There is no closed season for mussels, and a minimum size of 50 mm would apply in a public fishery. These were formerly exploited by the same harvester, but this has not occurred for more than six years.

4.2. Hygiene Classification

Table 4.1 lists all classifications within the survey area since 2005.

Table 4.1: Classification history for the Alde, 2004 onwards

Area	Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Home Reach	P. oyster	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	-	-	-
Westrow Reach	Mussels	B-LT	B-LT	B-LT	B-LT	-	-	-	-	-	-
Martello Tower	Mussels	B-LT	B-LT	B-LT	B-LT	-	-	-	-	-	-
South Westrow	Mussels	B-LT	B-LT	B-LT	-	-	-	-	-	-	-

LT denotes long term classification

Mussels have not been classified since 2008. The oyster site was temporarily declassified in 2012, and is currently sampled on a quarterly basis to maintain this status.

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 subject of this survey is a small Pacific oyster farm which is not currently active. Oysters were formerly ongrown here from seed to a market size in mesh bags hung between wooden posts and sold to local markets. This apparatus covers only a small fraction of the lease area. A minimal amount of mature stock remains on site, which is held for sampling purposes. Although the harvester has expressed an interest in restocking the site, future prospects are uncertain. The fishery is not subject to any conservation controls and harvest may occur at any time of the year. It was temporarily declassified in 2012, and since then this status has been maintained via quarterly sampling.

The same harvester also used to exploit naturally occurring mussels in the stretch upstream of the oyster farm, but has not done so for at least 6 years. Aside from the maximum extent of the former classified zone little is known about these stocks. For the purposes of producing a sampling plan in case it may be required in the future, the former classified zone will be used as the zone boundary, and it will be assumed that bagged mussels will be used if there is no stock available at the recommended sampling point(s). Any mussel classification should be year round, and it is advised that the LEA confirm with anyone requesting such a classification that they are entitled to harvest there.

5.3. Pollution Sources

Freshwater Inputs

The Alde/Ore estuary upstream of the Butley confluence has a hydrological catchment of 246 km^2. The three main freshwater inputs (Rivers Alde, Ore and Fromus) drain about 70% of this catchment between them. They all enter the estuary at its head, which is about 10 km from the oyster farm. There are flow gauging stations on the lower reaches of the Alde and Ore, which indicate that the both have a mean discharge of about 0.5 m^3/sec. The relatively small volumes of runoff delivered and the distance from the fishery would suggest that their impacts will be minor. No bacteriological testing results were available for these watercourses.

Flows at both were higher on average during the colder months of the year. High flow events tended to occur from December through to May, and were of a higher magnitude on the Alde than on the Ore. High flow events are likely to be associated with increased fluxes of faecal indicator bacteria into the estuary. It is uncertain whether the seasonal variation in average flows translates to a similar variation in the average bacterial loading delivered by these watercourses.

The low lying land at the Iken, Sudbourne and Gedgrave Marshes are drained by pumping stations. They have maximum capacities of 0.35, 0.5 and 0.5 m^3/s respectively. The small watercourse that originates in Sudbourne village drains to the Iken Marshes, so will enter the estuary via the Iken pumping station. These pumping stations will only operate for a small fraction of the time, and will be much more active during the colder months of the year. A sample taken during the shoreline survey from the ditch behind the Sudbourne pumping station contained only 90 *E. coli* cfu/100ml, and the pumps were not in operation at the time. The other two pumping stations were outside of the area surveyed.

The Aldeburgh Marshes are drained by a gravity sluice, and a small floating pump was also observed in operation here at the time of the shoreline survey. The discharge rates and *E. coli* concentrations from these locations measured during the shoreline survey were 0.124 and 0.012 m^3/sec and 110 and 90 *E. coli* cfu/100ml respectively. As such the bacterial loadings they were delivering at the time were not particularly large (1.2×10^{10} and 9.3×10^8 *E. coli*/day respectively) and it is concluded that the sluice outfall is more significant than the pumped outfall. This is the closest confirmed point source to the fishery.

Human Population

Total resident population within census areas contained within or partially within the catchment area was approximately 31,000 at the time of the last census. Most of the catchment is sparsely populated, and the main settlements are Framlingham, Saxmundham and Aldeburgh. The first two lie inland in areas which drain to the head of the estuary, whereas Aldeburgh lies on the coast just north of where the estuary bends round and heads inland. The smaller town of Orford is located on the banks of the estuary about 7 km downstream of the fishery.

Significant seasonal increases in population are anticipated at Aldeburgh, which is a popular holiday resort where Anglian Water estimates that the population doubles during peak periods. It is likely that there are also significant numbers of visitors to Orford. These population increases will result in a corresponding increase in the amount of effluent received by sewage works serving the area. Such large influxes of tourists are not generally anticipated at more inland locations.

Sewage Discharges

There are five water company owned sewage works of potential relevance to the shellfishery, all of which are remote from the fishery so will be of limited impact. Their combined consented dry weather flow is 2,897 m^3/day. The majority of this originates from the Benhall (Saxmundham) STW (1,500 m^3/day) and the Framlingham STW (1,000 m^3/day). These both provide tertiary treatment via sand filtration and discharge to watercourses draining to the head of the estuary, at distances of about 4 and 16 km upstream of the tidal limit at Snape, which is in turn about 10 km up-estuary from the oyster farm. Whilst the additional tertiary treatments are aimed at nutrient removal, they will also result in improved microbiological quality of the effluent as well, although not to the same extent as processes specifically designed for disinfection. Together with their remoteness from the fishery this will limit their impacts, although they will make some contribution to the bacterial loading carried by the watercourses they discharge to. A further contribution will be made by the Blaxhall STW, which provides secondary treatment for a dry weather flow of 159 m^3/day and discharges to the River Alde about 2.5 km upstream of the tidal limit. Sudbourne STW discharges to a small watercourse which feeds into the marsh network of ditches draining the Iken Marshes, and provides secondary treatment for a dry weather flow of 50 m^3/day. Again, some bacterial die-off is likely to occur during transit to the estuary, particularly given the sluggish nature of flows within the marsh drains. Gedgrave STW is located approximately 9 km downstream of the shellfisheries and discharges to a marsh drain which feeds into the estuary south of Orford. Whether effluent from this outfall is carried as far as the shellfishery will depend on the strength of tidal currents in this part of the estuary.

A sixth works (Aldeburgh STW) discharges to the North Sea via a long sea outfall and so will have no influence on water quality in the estuary. Finally, there is a very small sewage works in the very upper reaches of the catchment (Brundish STW) which is consented to discharge 5 m^3/day of effluent to soakaway which will also have no impact on the fishery.

There are 12 intermittent discharges associated with the sewer networks in the survey area. No spill records were available for any of these at the time of writing, so it is difficult to assess their impacts apart from noting their location and potential to discharge sewage. Nine of them discharge to watercourses which enter the head of the estuary (the Alde, Ore and Fromus), and two discharge to watercourses in the Sudbourne area which drain to the estuary via the Iken Marshes. These will contribute to the bacterial loadings delivered by these watercourses, but again are relatively remote from the fishery so are unlikely to be a major influence. The last intermittent discharge is via the Aldeburgh STW outfall to the North Sea so should be of no impact on the estuary.

Although most properties are served by water company sewerage infrastructure, there are also 400 permitted private discharges within the survey catchment. These are generally treated by small package treatment plants or septic tanks, and the majority of these are small, serving one or two properties. A few (25) discharge to soakaway so should be of no impact to the estuary. Of the 375 discharging to water, the vast majority (364) are to watercourses which drain to the head of the estuary. These will therefore contribute to the bacterial loading delivered by the Alde, Ore and Fromus. Additionally there are a small number around Sudgrave and Orford which will make minor contributions to watercourses draining these areas. There is also a permit for a small private discharge (3 m^3/day of package plant treated effluent) direct to the estuary from a public convenience at Slaughden. The exact location could not be confirmed either on the shoreline survey or by the Environment Agency, and it is uncertain whether it is still in use but if it is, its impacts (if any) would be best captured by an RMP at the up-estuary end of the oyster farm.

It is concluded that the majority of sewage effluent will be delivered to the estuary by watercourses draining to its tidal limit at Slaughden. As this is about 10 km up-estuary from the oyster farm, their impacts will not be particularly acute. Some sewage effluent also feeds into ditches draining the Iken Marshes, and the Orford area, but these are relatively minor and also remote from the fishery. There is purportedly a small private discharge to the estuary at Slaughden, but the exact location of this could not be confirmed and it is uncertain whether it is still in use.

Agriculture

The majority of the land within the survey catchment is used for agricultural purposes, mostly for the cultivation of crops but there are also some areas of pasture, most of which is grazing concentrated around the estuary and along the banks of the main watercourses. At the time of the last detailed census (2010) there were 5,015 sheep, 2,279 cattle, 14,884 pigs and 311,844 poultry on farms within the catchment so there are significant numbers of grazing animals, as well as several pig and poultry rearing units. During the shoreline survey numerous cattle and sheep were observed on reclaimed fields in the Sudbourne Marshes and the Aldeburgh Marshes. These were generally fenced off from the shore, although in one place just north of Orford cattle had recently accessed a small strip of unfenced saltmarsh at the water’s edge.

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 farmlands. This in turn may 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’). The geographical distribution of pasture suggests that the various grazing marsh drains and the Rivers Alde and Ore may be most heavily impacted by grazing animals. The extent of these impacts will be influenced by the amount of access livestock have to these watercourses. The spatial pattern of application of organic fertilisers (manures, slurries and sewage sludge) to arable crops is uncertain, but arable land is widespread throughout the catchment so most, if not all, watercourses may be impacted at times.

There is likely to be some seasonality in fluxes of agricultural contamination. Numbers of sheep and cattle will increase in the spring with the birth of lambs and calves, and decrease in the autumn when animals are sent to market. Livestock are likely to access any unfenced watercourses to drink and cool off more frequently during the warmer months. The seasonal pattern of application of manures and slurries to farmland is uncertain, although as the area is within a nitrate vulnerable zone spreading is not permitted during the winter. Therefore peak levels of contamination from livestock 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 and possibly more intense basis if wet weather follows a slurry application, which is not permitted during the winter.

Boats

Boat traffic in the area consists of large numbers of yachts and other pleasure craft, together with a small number of tour boats. The fishing fleet that operates from Aldeburgh launches from the beach straight into the North Sea so fishing vessels are not a regular presence in this part of the estuary, although a small number do operate from Orford Quay. Pleasure craft activity centres around Slaughden and Orford, where there are yacht clubs with some on shore facilities and numerous yacht moorings. None of these yacht clubs have sewage pump-out facilities however. The oyster fishery lies at the downstream end of the moorings at Slaughden, where over 130 boats were observed during the shoreline survey, at least four of which were occupied. As such the moorings at Slaughden represent a potentially significant source of contamination to the fishery.

Private vessels such as yachts, motor cruisers and fishing vessels of a sufficient size are likely to make overboard discharges from time to time. This may either occur when the boats are moored or at anchor, particularly if they are in overnight occupation, or while they are navigating through the area. Whilst overboard discharges may be made anywhere within the survey area by navigating vessels, it is likely that the moorings areas are most at risk of contamination from this source. Peak yachting 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 Alde estuary encompasses a variety of habitats including intertidal mudflats and saltmarsh which attract aggregations of wildlife. The most significant wildlife aggregation of relevance to shellfish hygiene is likely to be overwintering waterbirds (waders and wildfowl). Over the five winters up until 2011/2012 an average maximum count of 33,908 overwintering waterbirds were recorded within the Alde/Ore estuary complex. On the shoreline survey no major aggregations of birds were observed. Grazers, such as geese and ducks will mainly frequent the saltmarsh and coastal grasslands where their faeces will be carried into coastal waters via land runoff or through tidal inundation. Therefore RMPs within or near to the drainage channels from watercourses and saltmarsh areas will be best located to capture contamination from this source.

Waders will forage on intertidal invertebrates and will represent a diffuse source of contamination direct to intertidal areas. They may tend to aggregate in certain locations holding the highest densities of bivalves of their preferred size and species, but this will probably vary with time. At high tide waders are likely to frequent undisturbed areas such as saltmarsh and the perimeter of the estuary. Due to the diffuse and spatially unpredictable nature of contamination from wading birds it is difficult to select specific RMP locations to best capture their impacts, although they may be a significant contaminating influence during the winter months.

Whilst most of these birds migrate elsewhere to breed, there are significant resident and breeding populations of seabirds (gulls, terns etc) in the area. The main colony is at Orford Ness, where around 6,200 pairs of gulls were recorded in a survey in 2000. A smaller breeding colony of 612 pairs of gulls and terns was reported on Havergate Island. These seabirds are likely to forage widely throughout the area so inputs could be considered as diffuse, but are likely to be most concentrated in the immediate vicinity of the nest sites. As both the breeding colonies are remote to the fishery, their impacts here will be diffuse and will not influence the sampling plan.

A limited microbial source tracking study undertaken by the Environment Agency in 2008 detected both human and ruminant contributions to faecal contamination in the area, but did not detect any avian contribution. The limited data tentatively suggests that birds are not a major influence in the Home Reach area.

Harbour seals are thought to visit the estuary from time to time but in small numbers. No regular haul-out sites within the estuary have been identified. Their impacts will be minor at most and spatially and temporally unpredictable, and so will have no bearing on the sampling plan. There are also a few otters present in the area, but the conclusions on their potential impacts are similar to those of seals. No other wildlife species which may affect the sampling plan have been identified.

Domestic animals

Dog walking takes place on 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 accessible paths such as those at Slaughden and on the Aldeburgh Marshes. 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.

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

Pollution source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Agricultural runoff	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange
Continuous sewage discharges	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Intermittent sewage discharges	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Urban runoff	White	White	White	White	White	White	White	White	White	White	White	White
Birds	Orange	Orange	Orange	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange
Boats	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange	Orange	Yellow	Yellow	Yellow

Red - high risk; orange - moderate risk; yellow - lower risk; white - little or no risk.

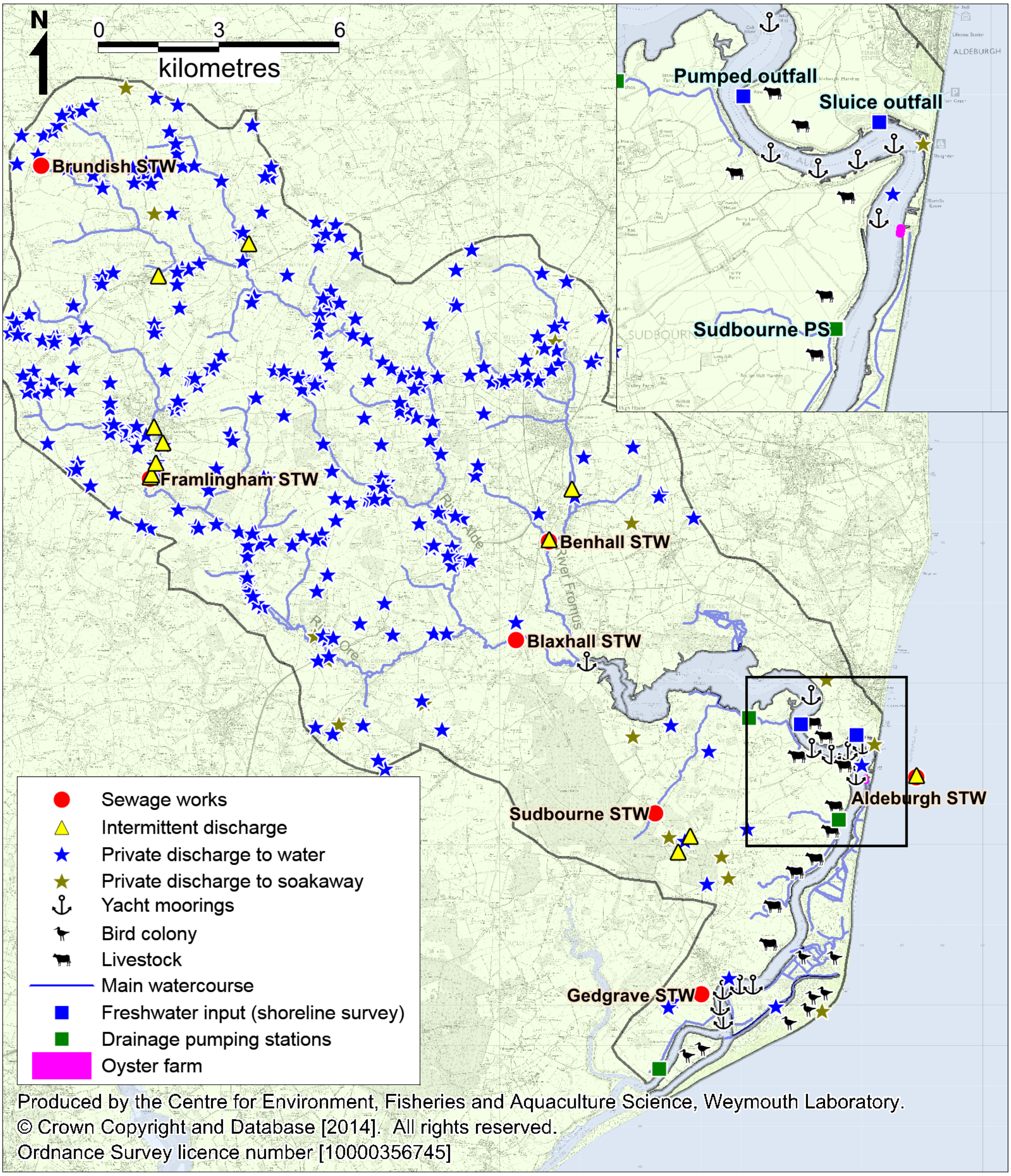


Figure 5.1: Summary of main contaminating influences

Hydrography

The Alde/Ore is a spit enclosed estuary that has a long and narrow main channel of about 26 km from mouth to tidal limit, and is less than 300 m in width for much of its length. The main channel averages about 5 m in depth (relative to chart datum) and intertidal areas are generally limited to narrow strips. It runs parallel to the coast behind a shingle bar for most of its length before heading inland and opening out into a wider, shallower tidal basin with more extensive intertidal areas. There are two side arms in the middle reaches (Butley and Stony Ditch) at either end of where the channel splits around Havergate Island. The main channel shallows slightly to 2 m depth just to the south of the oyster farm. The main freshwater inputs are minor rivers which drain to the head of the estuary at Snape.

Tides are the main driver of water circulation within the estuary. The tidal range at Slaughden is 2.3 m on spring tides and 1.6 m on neap tides. Tidal streams move up the estuary on the flood, and back out on the ebb. Therefore, shoreline sources will impact either side of their location, along the same shore, and the magnitude of their impacts will decrease with distance as the plume spreads. No firm information on current speeds in the vicinity of the fishery could be found. The maximum current velocity at the mouth of the estuary where current speeds are highest was reported to be 1.63 m/s, so it can be tentatively inferred that maximum tidal excursion is unlikely to exceed about 15 km. As such, contamination from sources downstream of the Butley confluence are unlikely to be carried as far as the fishery before the tide turns. When this is considered together with the length and depth of the estuary, it is likely that flushing of contamination from the upper reaches is a relatively slow process. No reliable sources of information could be found to confirm this however.

Freshwater inputs to the Alde/Ore estuary are minor in relation to tidal exchange so the estuary as a whole is considered well mixed, and density driven circulation is unlikely to be of significance. This may not necessarily apply to the upper reaches where the main freshwater inputs are located, particularly at times of high river discharge. Should localised density effects arise in the upper reaches these will result in a net outflow of less saline water at the surface, with a corresponding return of more dense, saline water at depth.

Repeated salinity measurements were made between 2004 and 2013 at the shellfish waters monitoring point at Home Reach, and a few salinity measurements were taken during the winter months at four further locations in the upper estuary from Barbers Point down to Blackstakes Reach. The average salinity at Home Reach was 24.4 ppt and ranged from 11.7 to 31.6 ppt. These measurements indicate a significant proportion of the water in the upper estuary originates from land runoff, particularly during the winter months. Across the other four sites, there was a gradual decrease in salinity towards the upstream end, but the gradient was very slight with a drop in average salinity of less than 3 ppt over an 8 km stretch. The gradient in average salinity across the shellfishery will therefore be negligible.

In many situations, decreasing salinities are generally associated with higher concentrations of run-off borne contamination in the water column. However, lower salinities at Home Reach were not associated with higher levels of faecal indicator bacteria in surface water samples. This may be a consequence of lengthy flushing times in relation to the speed of bacterial die-off, meaning the decreased salinity following a runoff event persists for longer than the faecal indicator bacteria washed into the estuary during the event. The large distance between the main freshwater inputs and the fishery is also likely to be a factor.

Winds may modify circulation patterns, as they drive surface currents which in turn create return currents at depth or along sheltered margins. The prevailing south westerly winds will tend to push surface water up the estuary in the vicinity of the fishery, but will have the opposite effect upstream of the sharp bend at Slaughden. 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. Where these waves break contamination held in intertidal sediments may be re-suspended, although given the enclosed nature of the estuary strong wave action is not generally anticipated.

5.4. Summary of Microbiological Data

The survey area has been subject to limited microbiological monitoring over recent years, deriving from the Shellfish Waters monitoring programme, and shellfish flesh monitoring for hygiene classification purposes. Figure 5.2 shows the locations of the monitoring points referred to in this assessment. Results from 2004 onwards are considered in these analyses.

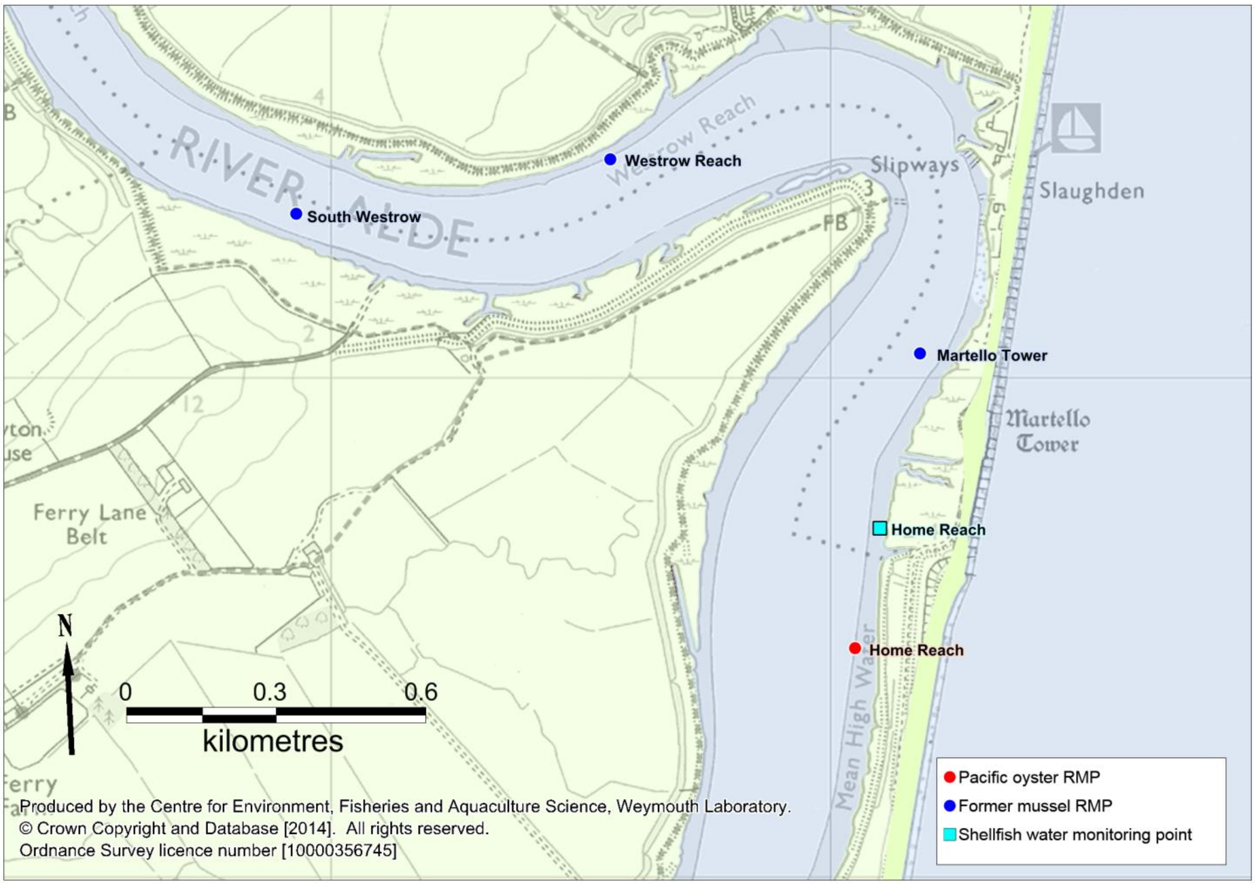


Figure 5.2: Location of microbiological sampling sites.

Shellfish Waters

There is one shellfish waters monitoring point within the survey area (Home Reach) where water samples have been taken on a quarterly basis and enumerated for faecal coliforms. From 2004 to the time of writing a total of 43 samples were taken here. Levels of faecal coliforms in the water column did not vary greatly, with a geometric mean result of 8.3 cfu/100ml, few results exceeding 100 cfu/100ml, and a maximum result of 144 cfu/100ml. No trends of increasing or decreasing results were apparent through the period considered. Some seasonal variation was apparent, with lower results in the spring relative to other seasons. Statistical analyses indicated that results were significantly higher in the summer compared to the spring. A statistically significant influence of the high/low tidal cycle on faecal coliform concentrations was found. A plot of the data showed faecal coliform concentrations tended to be higher on average towards the end of the ebb tide, suggesting upstream sources are an influence. No significant influence of the spring/neap tidal cycle was detected. Faecal coliform concentrations increased significantly two days after a rainfall event. After two days rainfall the effect was no longer significant, but the low numbers of samples and consistent influence of cumulative totals suggest that if further results were considered then the influence of rainfall events may be more prolonged. In apparent contradiction to this, no correlation was found between salinity and faecal coliform concentrations. It is possible that this lack of association was a consequence of the length of time required to flush a pulse of freshwater from the system in relation to bacterial die-off times, and/or the remoteness of the main freshwater inputs.

Shellfish Hygiene monitoring

There are four RMPs which have been sampled between 2004 and 2014, three of which are for mussels and one is for Pacific oysters, where monthly flesh samples were taken and enumerated for *E. coli*. Mussel sampling ceased in 2005 at Martello Tower, in 2007 at South Westrow, and in 2008 at Westrow Reach. Pacific oyster sampling continues at Home Reach, although the frequency dropped to quarterly in 2011.

Across the three mussel RMPs the geometric mean results were 140 *E. coli* MPN/100g at Westrow Reach, 119 *E. coli* MPN/100g at South Westrow and 93 *E. coli* MPN/100g at Martello Tower. The only result exceeding 4600 *E. coli* MPN/100g was recorded at Westrow Reach. There was no statistically significant difference in average result across these three RMPs, and the results of paired (same day) samples were strongly correlated between all site parings. From this it may be concluded that there is no major increase in levels of contamination towards the up-estuary RMP, and that all three RMPs are influenced by similar sources of contamination. There may be a minor source of contamination of local significance to Westrow Reach responsible for the slightly higher results here, possibly the freshwater sluice outfall seen on the shoreline survey.

The geometric mean result for Pacific oysters at Home Reach was 90 *E. coli* MPN/100g, and 3% of samples exceeded 4600 *E. coli* MPN/100g. The highest result recorded was >18,000 *E. coli* MPN/100g.

No overall temporal trends in results were apparent at any of these four RMPs since 2004. Similar seasonal patterns were observed at all four RMPs, with a tendency for higher results on average during the summer and autumn compared to spring and winter. Seasonal variation was more marked, and statistically significant at South Westrow, where results were significantly higher in summer and autumn than in spring, and Home Reach where results were significantly higher in autumn than spring and winter.

Statistically significant associations were found between tidal state on both the high/low and spring/neap cycles for Home Reach, but not for any of the three mussel RMPs. Across the high/low tidal cycle there was an absence of very low results around low water, and the highest results arose during the second half of the flood tide. Across the spring/neap cycle results were similar on average, but the peak results occurred just after spring tides. It was only possible to investigate the influence of rainfall for a limited number of samples from Home Reach as rainfall records were only available from 2010 onwards. Nevertheless, there were sufficient records to determine that antecedent rainfall has no influence on *E. coli* levels in Pacific oysters at Home Reach. This is in contrast to the positive correlations observed between recent rainfall and faecal coliforms in the water column, possibly due to reduced oyster feeding rates at times of lower salinity and colder temperature.

Bacteriological survey

The very small footprint of the Pacific oyster farm and remoteness of contaminating influences meant that there was little point in undertaking a bacteriological survey to assess spatial variation across it. Some information on spatial variation in levels of contamination across the mussel fishery was already available deriving from the classification monitoring results from three historic mussel RMPs.

Appendices

Appendix I. Human Population

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

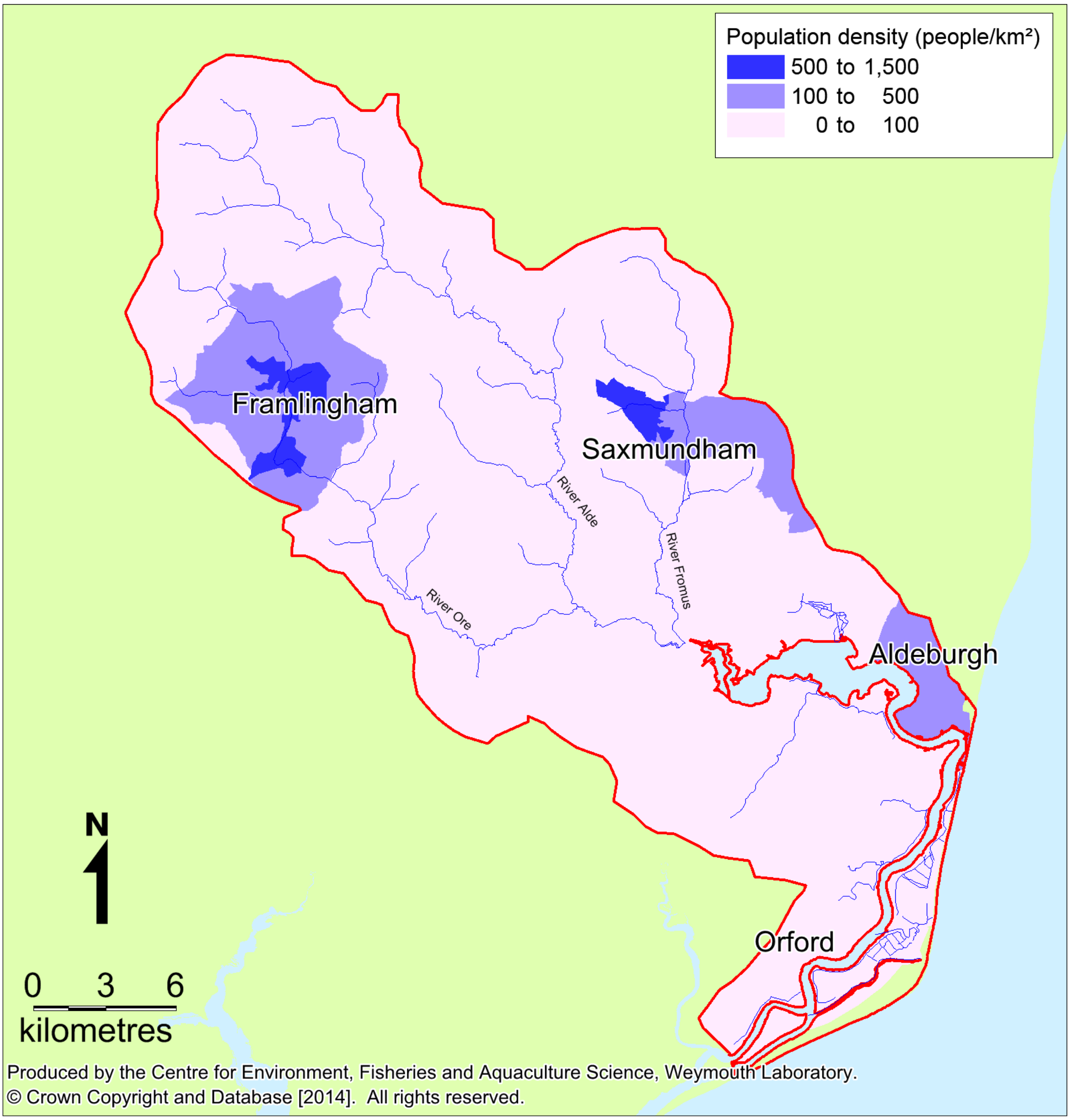


Figure I.1: Human population density in census areas in the River Alde catchment.

Total resident population within census areas contained within or partially within the catchment area was approximately 31,000 at the time of the last census. The majority of the catchment has a population density of lower than 100 people/km², including the census areas in which Orford is located. The largest settlements in the area are Framlingham, Aldeburgh and Saxmundham, which have populations of approximately 3,100, 2,800, and 2,700 respectively.

There are no statistics available for tourism in the River Alde catchment area. There are some nearby tourist attractions such as the Suffolk Coast & Heaths Area of Outstanding Natural Beauty and historic sites. Aldeburgh is a popular seaside resort. Information supplied by Anglian Water during the consenting process for Aldeburgh STW indicates it serves a maximum population comprising of 3,492 residents, 2,720 residential tourists and 2,000 day visitors. The populations of Saxmundham and Framlingham may increase slightly during peak periods, but this is unlikely to cause a significant increase in the levels of sewage. The population of Aldeburgh however may more than double during holiday periods and as such an increase in volumes of sewage during that time is likely.

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

Details of all consented sewage discharges within the River Alde hydrological catchment were taken from the most recent update of the Environment Agency national permit database (March 2014). These are mapped in Figure II.1.

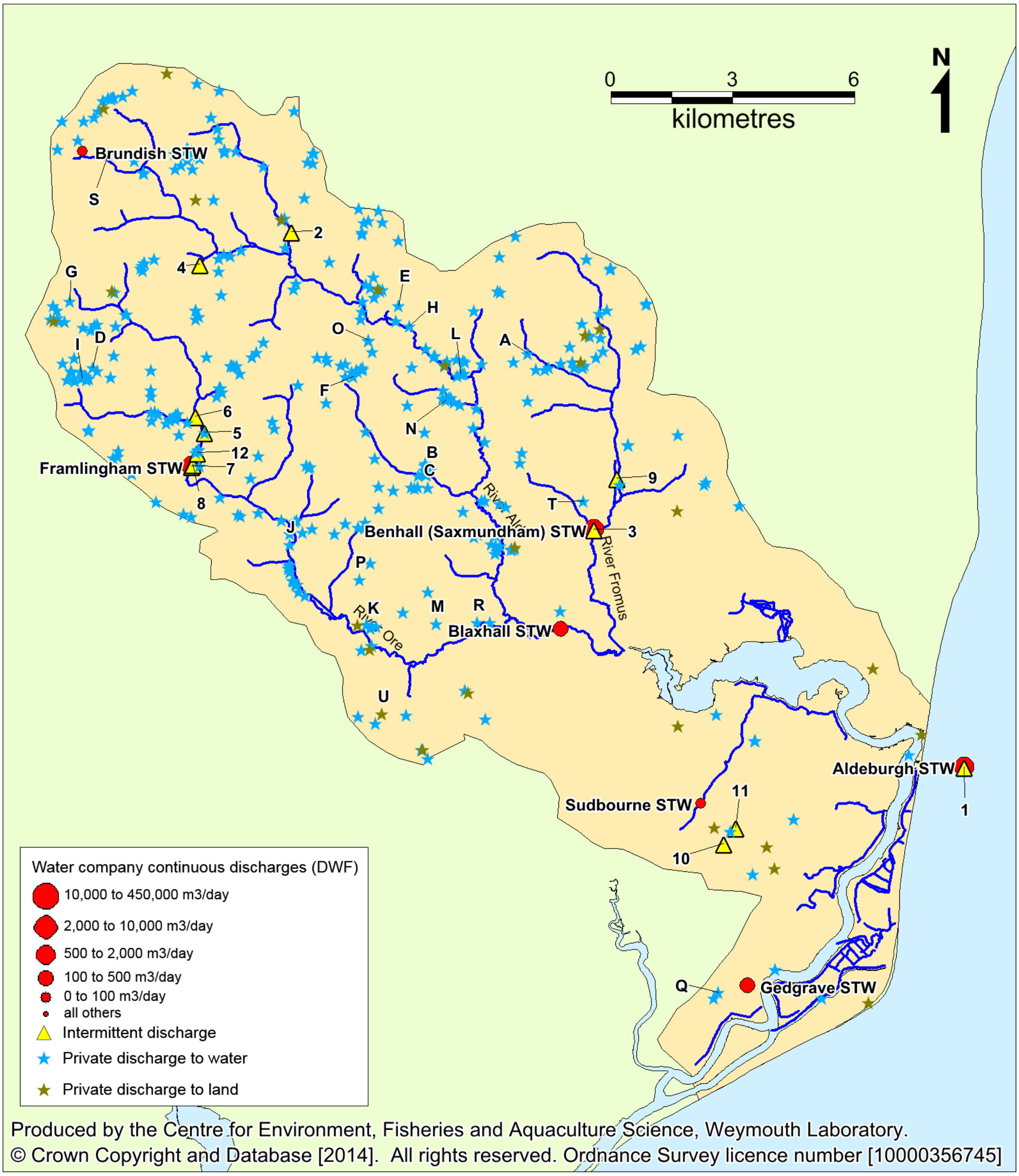


Figure II.1: All permitted sewage discharges to the River Alde catchment
Contains Environment Agency information © Environment Agency and database right

There are seven water company sewage works discharging within the survey area, details of which are presented in Table II.1.

Table II.1: Details of continuous water company sewage works within the survey area

Name	**NGR**	**Treatment**	**DWF (m^3/day)**	**Estimated bacterial loading (cfu/day)***	**Receiving environment**
Aldeburgh STW	TM47355470	Biological Filtration	1196	3.95×10^{12}	North Sea
Benhall (Saxmundham) STW	TM38226056	Sand Filtration	1500	Unknown	River Fromus
Blaxhall STW	TM37405810	Biological Filtration	159	5.25×10^{11}	River Alde
Brundish STW	TM25606990	Unspecified	5	Unknown	Soakaway
Framlingham STW	TM28296212	Sand Filtration	1000	Unknown	River Ore
Gedgrave STW	TM42004930	Biological Filtration	188	6.20×10^{11}	Marsh Drain
Sudbourne STW	TM40865380	Submerged Aerated Filter	50	Unknown	River Alde trib.

Contains Environment Agency information © Environment Agency and database right

*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	7.2×10^6
Primary (12)	127	1.0×10^7	14	4.6×10^6
Secondary (67)	864	3.3×10^5	184	5.0×10^5
Tertiary (UV) (8)	108	2.8×10^2	6	3.6×10^2

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

Aldeburgh STW discharges to the North Sea offshore from the estuary so the effluent will have no impact on the shellfisheries.

Three sewage works discharge to watercourses which drain to the head of the estuary at Snape, about 10 km up-estuary from the oyster farm. The bulk of the effluent discharging to these watercourses originates from the Benhall (Saxmundham) STW and the Framlingham STW which discharge 4 and 16 km upstream of the tidal limit at Snape. These both provide tertiary treatment via sand filtration, which is aimed at nutrient reduction rather than disinfection of the effluent, although it will provide some improvement of the microbiological quality of the effluent. There is one smaller works (Blaxhall STW) which discharges secondary treated affluent to the River Alde about 2.5 km upstream of its tidal limit. These three works will contribute to the bacterial loading delivered to the head of the estuary by the main watercourses.

Sudbourne STW discharges to a small watercourse which feeds into the marsh network of ditches draining the Iken Marshes. This discharge is the closest continuous water company discharge and although its treatment level is unspecified, it is unlikely to have any major impact on the shellfisheries given its small size and distance from them. Gedgrave STW is located approximately 9 km downstream of the shellfisheries and discharges to a marsh drain which feeds into the estuary south of Orford. Whether effluent from this outfall is carried as far as the shellfishery will depend on the strength of tidal currents. The only other continuous water company discharge, Brundish STW, discharges to soakaway at the very head of the catchment and is very small (DWF 5 m^3/day) and as such will be of no relevance to the shellfisheries. As all the continuous water company discharges are located at some distance from the shellfisheries, some natural die-off of micro-organisms is likely to occur between the point of discharge and the shellfisheries, depending on their size, treatment level and on river transit times.

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

Table II.3: Intermittent discharges to the River Alde catchment

No.	Name	Grid reference	Receiving water	Type
1	Aldeburgh STW	TM4735054700	North Sea	Storm Overflow/ Storm Tank
2	Badingham PS	TM3075067910	River Alde	Pumping Station
3	Benhall(Saxmundham) STW	TM3822060560	River Fromus	Storm Overflow/ Storm Tank
4	Dennington PS	TM2850067110	River Alde trib.	Pumping Station
5	Fairfield Road	TM2861062960	River Ore	Sewer Storm Overflow
6	Fore Street	TM2839063350	River Ore	Storm Overflow/ Storm Tank
7	Framlingham STW	TM2829062120	River Ore	Emergency Discharge
8	Framlingham STW	TM2833062170	River Ore	Storm Overflow/ Storm Tank
9	Sternfield PS	TM3878061820	River Fromus	Sewer Storm Overflow
10	Sudbourne PS No1	TM4142052800	River Alde trib.	Pumping Station
11	Sudbourne PS No2	TM4172053190	River Alde trib.	Pumping Station
12	Woodbridge Rd CSO	TM2844062460	River Ore	Storm Overflow/ Storm Tank

Contains Environment Agency information © Environment Agency and database right

There are 12 intermittent discharges in the survey area. No spill records were available for any of these at the time of writing, so it is difficult to assess their impacts apart from noting their location and potential to discharge sewage. Five are for emergency discharges only (e.g. pump failures or blockages) whereas the other seven are storm overflows and so may operate if the sewers become overloaded following heavy rainfall. Nine of them discharge to watercourses which enter the head of the estuary (the Rivers Alde and Fromus), and two discharge to watercourses in the Sudbourne area. These will contribute to the bacterial loadings delivered by these watercourses, but are relatively remote from the fishery so are unlikely to be a major influence. The last intermittent discharge is via the Aldeburgh STW outfall to the North Sea so should be of no impact on the estuary.

Although most properties within the survey area are served by water company sewerage infrastructure, there are also a number of private discharges. Where specified, these are generally treated by small package treatment plants or septic tanks, and the majority of these are small, serving one or two properties. All permitted private sewage discharges are mapped in Figure II.1, and Table II.4, presents details of those consented to discharge more than 5 m^3/day.

Table II.4: Details of private sewage discharges >5 m^3/day to the River Alde catchment

Ref.	Property served	Location	Treatment type	Max. daily flow (m^3/day)	Receiving environment
A	Blyth Row	TM3660064900	Reedbed	132	River Fromus trib.
B	Blyth Villas Sweffling	TM3420062030	Unspecified	12	River Alde trib.
C	Bruisyard Hall	TM3414061590	Unspecified	12	River Alde trib.
D	Chapel Lane	TM2587064560	Unspecified	12	River Ore trib
E	Cransford Hall	TM3340666090	Package Plant	10.2	River Alde trib.
F	Cransford Housing Dev.	TM3229064340	Unspecified	10	River Alde trib.
G	Fox Earth Nursing Home	TM2530066200	Unspecified	10	River Ore trib
H	Gt Glemham St Sewage	TM3368065580	Unspecified	9	River Alde
I	Hal Farm & Adj Buildings	TM2560064300	Package Plant	8.5	River Deben trib
J	Hall Road Marlesford	TM3072060180	Unspecified	8	River Ore
K	Lakeside Leisure Park	TM3275058180	Unspecified	6	River Ore
L	Rendham 12 Houses	TM3493064390	Package Plant	6	River Alde
M	Rendham Rd Houses	TM3433058230	Unspecified	6	River Ore trib
N	Richmond Farm	TM3458063750	Unspecified	5	River Alde trib.
O	Saxtead Green Houses	TM3266265240	Package Plant	5	The Meres Framlingham
P	Sink Farm Barn Conversion	TM3244059320	Unspecified	5	River Ore trib.
Q	Streetfield Cncl Hses	TM4129049130	Unspecified	5	River Ore
R	Sunnyside Cottages	TM3535058260	Unspecified	5	River Ore trib.
S	The Old Mill House Public House	TM2625069830	Unspecified	5	River Alde trib.
T	Whitearch Touring Van Park	TM3796761255	Package Plant	5	River Fromus trib.
U	Kingsley Care Homes Ltd	TM3300056000	Biological Filtration	12.5	Soakaway

Contains Environment Agency information © Environment Agency and database right

There are 375 permitted private sewage discharges to water, and 25 private discharges to soakaway within the catchment. Those discharging to soakaway should be of no impact on surface watercourses and coastal waters assuming they are functioning correctly. The vast majority of those discharging to water (364 of 375) are to watercourses draining to the head of the estuary so they will make some contribution to the bacterial loading delivered by Rivers Alde, Ore and Fromus. Additionally there are a small number in the Sudgrave and Orford areas. Finally, there is a private discharge to the Alde estuary at Slaughden listed in the permit database. It purportedly serves public conveniences at Slaughden and is consented to discharge up to 3 m^3 of package plant treated effluent per day. The outlet location is specified as TM 46000 55000, which is about 300 m upstream of the oyster fishery, but towards the opposite side of the river. It seems likely that the grid reference was rounded down, and that the actual location of this discharge lies somewhere in the 1 km square extending north and east from this point. No sign of this discharge was observed during the shoreline survey. The Environment Agency advised that the permit has changed hands a couple of years ago but could not confirm whether it is still in operation, and if so where it is located exactly. Suffolk Coastal District Council advised that the public toilets at Slaughden Quay car park are connected to the mains sewer. Even if it is still discharging somewhere along Slaughden Quay, its influence on the fishery will be minor given the small volumes involved. An RMP at the up-estuary end of the shellfishery would best capture its impacts, if any.

Appendix III. Sources and Variation of Microbiological Pollution: Agriculture

The majority of the land within the survey catchment is used for agriculture, although there are significant parts of the south east of the catchment which are occupied by forestry. Most agricultural land is in arable use, but there are some areas of pasture, most of which is reclaimed land around the estuary with some further areas along the banks of the Rivers Ore and Alde (Figure 1.2).

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 more recent censuses were less detailed. 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 Alde catchment

Cattle		Sheep		Pigs		Poultry	
No.	Density (no/km^2)	No.	Density (no/km^2)	No.	Density (no/km^2)	No.	Density (no/km^2)
2,279	9.4	5,015	20.6	14,884	61.1	311,844	1280.7

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.

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

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

There are large numbers of poultry and pigs are farmed in the catchment, as well as some grazing animals (cattle and sheep). During the shoreline survey numerous cattle and sheep were observed on reclaimed fields in the Sudbourne Marshes and the Aldeburgh Marshes. These were generally fenced off from the shore, although in one place just north of Orford cattle had recently accessed a small strip of unfenced saltmarsh at the waters' edge.

Manure is either deposited directly on land by grazing animals or at outdoor pig farms. It is also collected from indoor cattle, pig or poultry units, and spread on farmland. This may in turn be washed into watercourses by rain which will carry it to coastal waters. As the primary mechanism for mobilisation of faecal matter deposited on farmland 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'). Contamination deposited on saltmarsh will be washed directly into the estuary when it is inundated on the larger spring tides.

The geographical distribution of pasture suggests that field drains from the grazing marshes which border the estuary in places, and the River Alde may be most at risk from grazing livestock. The extent of these impacts will be influenced by the amount of access livestock have to watercourses. The locations of outdoor pig farms are uncertain. The spatial pattern of application of organic fertilisers (manures, slurries and sewage sludge) to arable crops is uncertain, but arable land is widespread throughout the catchment so most, if not all of the larger watercourses may potentially be impacted at times.

There is likely to be seasonality in levels of contamination originating from livestock. Numbers of sheep and cattle will increase significantly in the spring, with the birth of lambs and calves, and decrease in the autumn when animals are sent to market. Livestock are likely to access unfenced watercourses to drink and cool off more frequently during the warmer months. In 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 the survey area is a nitrate vulnerable zone so spreading is subject to a closed period from September/October to the end of December or January, depending on soil and manure types. Therefore peak levels of contamination from grazing livestock may arise following high rainfall events in the summer, particularly if these have been preceded by a dry period which would allow a build up of faecal material on pastures, or on a more localised basis if wet weather follows a slurry application, which is not permitted during the late autumn and early winter.

Appendix IV. Sources and Variation of Microbiological Pollution: Boats

The discharge of sewage from boats is a potential source of bacterial contamination to shellfisheries within the survey area. Boat traffic primarily consists of recreational craft such as yachts. Figure IV.1 presents an overview of boating activity derived from the shoreline survey, satellite images and various internet sources.

Figure IV.1: Boating activity in the Alde survey area

There are no commercial ports or marinas within the estuary but there are numerous yacht moorings at Slaughden, near Aldeburgh and at Orford. Both Slaughden and Orford provide some on-shore facilities for visiting yachtsmen, but no sewage pump-out services (The Green Blue, 2010). On the shoreline survey over 130 boats were moored around Slaughden and of these at least four were observed to be occupied. The oyster fishery lies at the downstream end of this area of moorings.

There is a small fishing fleet in the area, of which 11 fishing vessels under 10 metres are listed as having Orford Quay or Aldeburgh as their home port (MMO, 2014). Those operating from Aldeburgh launch from the beach straight to the North Sea, whereas those based at Orford navigate through the outer estuary to reach the fishing grounds. Fishing vessels therefore do not usually frequent the estuary in the vicinity of the oyster fishery. A small number of vessels offering river cruises operate from Snape Maltings, Aldeburgh and Orford (Melton Hall website, 2014). Smaller pleasure craft such as sailing dinghies operate from the yacht clubs at Aldeburgh and Orford, but these do not have on board toilets and so are very unlikely to make overboard discharges

It is therefore concluded that boat traffic of relevance consists mainly of large numbers of yachts, a handful of tour boats and possibly the occasional fishing vessel. The main yachting centres are located at Slaughden and Orford where there are on-shore facilities and large numbers of vessel moorings. Of most relevance to the assessment, the moorings at Slaughden extend down to just upstream of the trestles. Private vessels such as yachts, motor cruisers and fishing vessels of a sufficient size are likely to make overboard discharges from time to time. This may either occur when the boats are moored or at anchor, particularly if they are in overnight occupation, or while they are navigating through the area. Whilst overboard discharges may be made anywhere within the survey area by navigating vessels, it is likely that the moorings areas are most at risk of contamination from this source. At least four yachts on moorings at Slaughden appeared to be occupied at the time of shoreline survey. Peak yachting 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 Alde estuary encompasses a variety of habitats including intertidal mudflats and sandflats, lagoons and saltmarsh which attract aggregations of wildlife. Consequently, the Alde/Ore estuary complex has been classified as a Special Area of Conservation (SAC), a RAMSAR site and a Special Protection Area (SPA). The survey area is also protected by several other international and national environmental legislations including a Site of Special Scientific Interest (SSSI), Havergate Island RSPB reserve and Orfordness-Havergate National Nature Reserve.

The most significant wildlife aggregation of relevance to shellfish hygiene is likely to be overwintering waterbirds (waders and wildfowl). Studies in the UK have found significant concentrations of microbiological contaminants (thermophilic campylobacters, salmonellae, faecal coliforms and faecal streptococci) from intertidal sediment samples supporting large communities of birds (Obiri-Danso and Jones, 2000). Over the five winters up until 2011/2012 an average maximum count of 33,908 overwintering waterbirds were recorded within the Alde/Ore complex (Austin *et al*, 2014). On the shoreline survey no major aggregations of birds were observed.

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

Whilst most of these birds migrate elsewhere to breed, there are significant resident and breeding populations of seabirds (gulls, terns etc) in the area. A census of these in the early summer of 2000 recorded 6,915 pairs within a 5 km radius of the Alde estuary (Mitchell *et. al,* 2004). The vast majority of these were in the vicinity of Orford Ness (in the south western perimeter of the survey area) where a total of 6,200 pairs of gulls were reported. A smaller breeding colony of 612 pairs of gulls and terns was reported on Havergate Island. These seabirds are likely to forage widely throughout the area so inputs could be considered as diffuse, but are likely to be most concentrated in the immediate vicinity of the nest sites. As there are no significant breeding colonies within the immediate vicinity of the fishery, their impacts here will be diffuse and will not influence the sampling plan.

The Environment Agency collected seven water samples from the Alde at Home Reach between August and December 2008 and applied various microbial source tracking techniques. Both human and ruminant contributions were detected, but no evidence of faecal contamination from avian sources was found in any of the samples (Environment Agency, 2009). However, the faecal coliform concentrations in these samples were low and sample numbers were limited.

Whilst there are major seal colonies on the North Norfolk coast, and the Essex estuaries support about 100 harbour seals (MMO, 2011), there are no seal colonies within the Alde/Ore estuary complex. Small numbers are likely to forage in the area from time to time, their impacts will be minor at most and spatially unpredictable, and so will have no bearing on the sampling plan. Otters are present throughout the survey area and frequent signs of otter activity have been recorded on the marshes surrounding the River Alde/Ore. No information on numbers was available but the population is likely to be small (Suffolk Wildlife Trust, 2012). Otters generally tend to favour the more secluded areas with access to watercourses. However, given their wide distribution and small numbers otters have no influence on the sampling plan.

.

Appendix VI. Meteorological Data: Rainfall

The monthly rainfall data for the Benhall weather station, which is located just south of Saxmundham, are plotted in Figure VI.1.

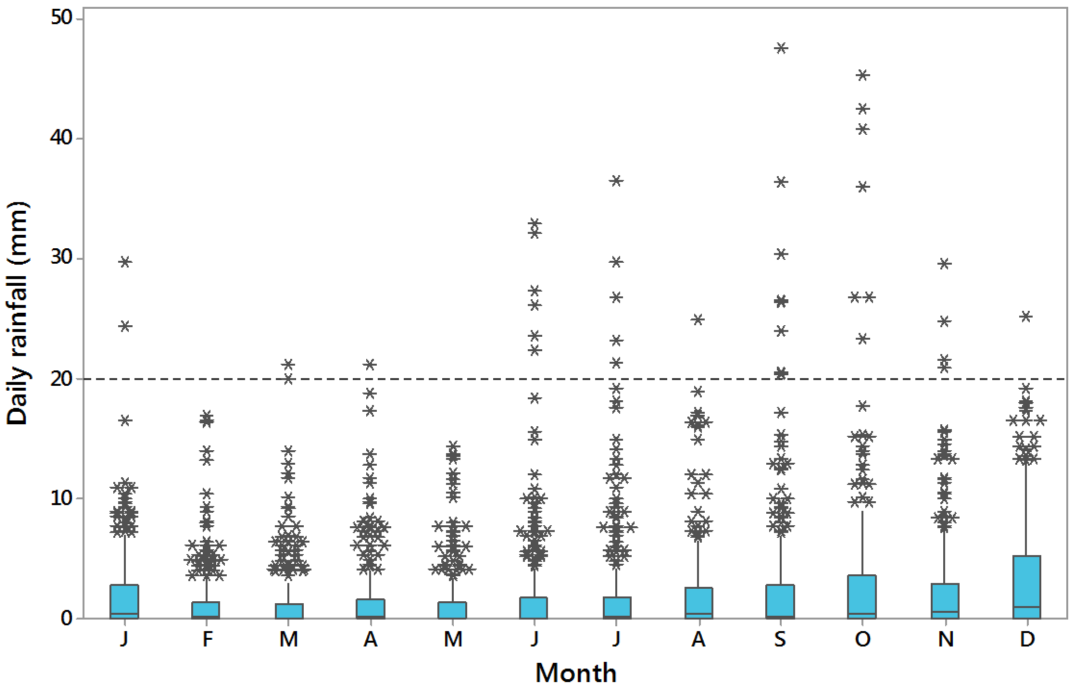


Figure VI.1: Boxplot of daily rainfall totals at Benhall, January 2010 to December 2013.
Contains Environment Agency information © Environment Agency and database right

The Benhall weather station received an average of 480 mm per year between 2010 and 2013. The autumn and winter months (October to January inclusive) had the highest average rainfall, while April to June (inclusive) had the lowest average rainfall. Daily totals of over 20 mm were recorded on 0.4% of days and no rainfall was recorded on 49% of days between 2004 and 2014. The majority of high rainfall events occurred 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

The strongest winds are associated with the passage of deep depressions and the frequency and strength of these is greatest in the winter (Met Office, 2012). As Atlantic depressions pass the UK, the wind typically starts to blow from the south or south-west, but later comes from the west or north-west as the depression moves away. Eastern England is one of the more sheltered parts of the UK, as the windiest areas are to the north and west, closer to the track of Atlantic storms. Figure VII.1 shows the wind rose for Coltishall, which lies about 65 km to the north of Aldeburgh.

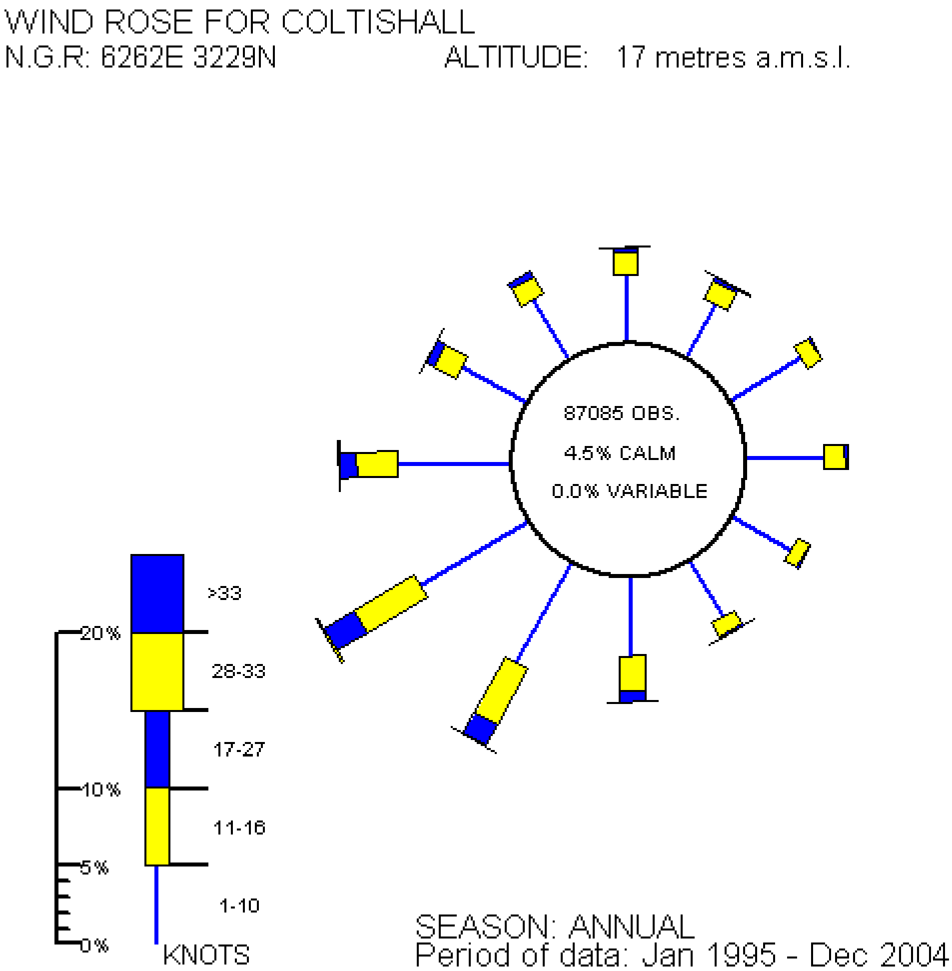


Figure VII.1 Wind Rose for Coltishall

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

The wind rose for Coltishall is typical of open, level locations across the region. There is a prevailing south-westerly wind direction throughout the year and the strongest winds usually blow from this direction. The frequency of gales is relatively low. During spring there is typically a higher frequency north-easterly wind's due to a build up of high pressure over Scandinavia (Met Office, 2012). Periods of very light or calm winds are more prevalent inland, with coastal areas having similar wind directions to inland locations but higher wind speeds. The Alde estuary has a west to east orientation in the upper reaches, bending round to a north to south direction at Aldeburgh. It is surrounded by low lying land and Orfordness Spit runs parallel and on the seawards side of the Alde/Ore estuary. These features offer a limited amount of shelter from the prevailing winds.

Appendix VIII. Hydrometric Data: Freshwater Inputs

The Alde/Ore estuary upstream of the Butley confluence has a hydrological catchment of 246 km² draining to it. There are three main freshwater inputs; the River Alde, the River Ore and the River Fromus (Figure VIII.1) which all enter at the head estuary via sluice gates. There are also three pumped outfalls which drain the reclaimed land bordering parts of the estuary.

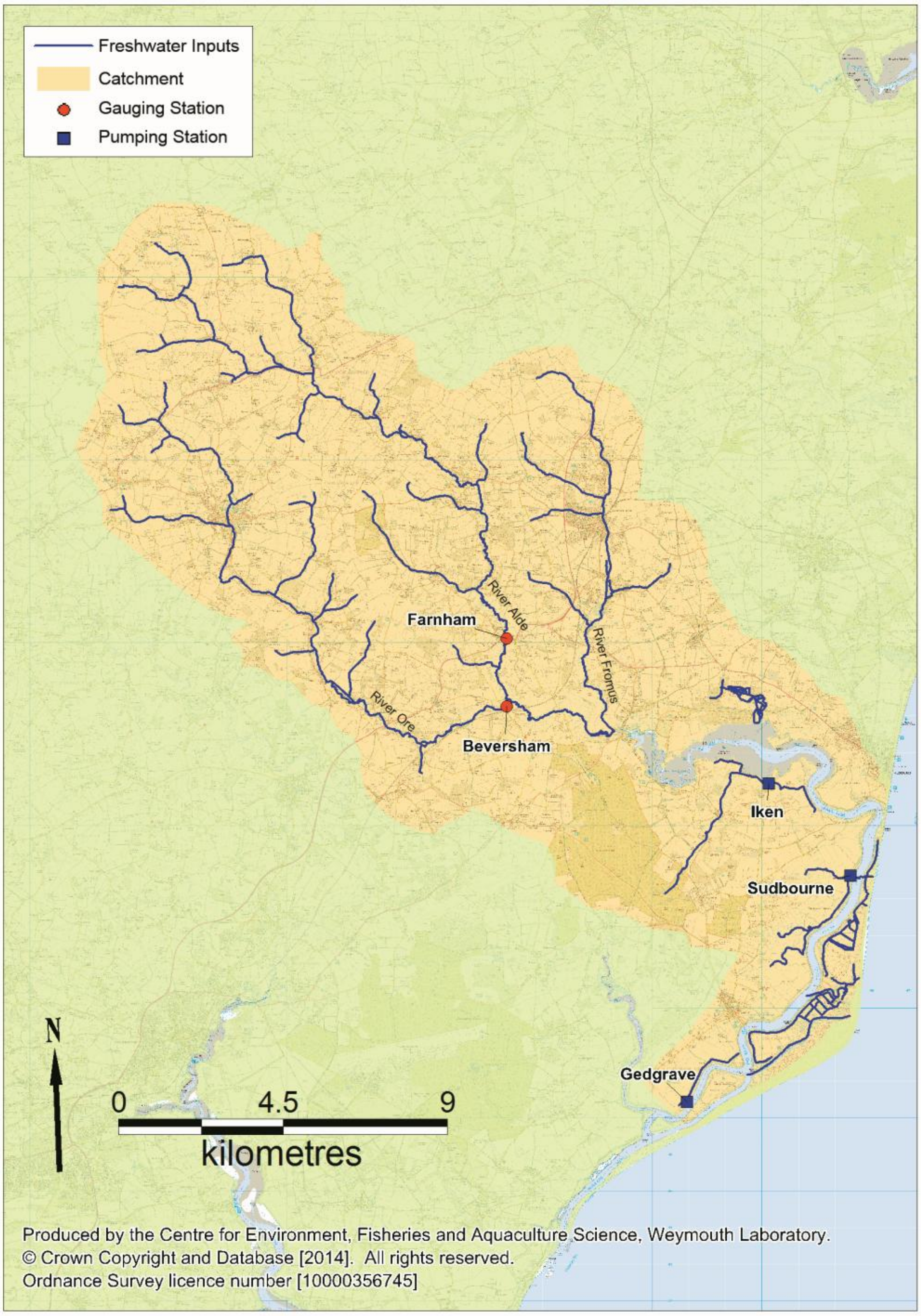


Figure VIII.1: Main watercourses and pumping stations in the Alde catchment

The Alde, Ore and Fromus watercourses originate from and flow through rural land, principally arable and horticultural farmland. The freshwater inputs, and the upper reaches of the estuary are flanked by strips of pasture. Urbanised land covers less than 4% of the catchment. The main settlements are limited to Framlington, Saxmundham, Orford and Aldeburgh, the latter two being situated close to the shore. Summary statistics for two flow gauges on the Alde and Ore are presented in Table VIII.1. Both have similar average discharge rates (0.453 and 0.483 m^3/s) and are of a similar size. The Fromus is smaller in length and drains a smaller catchment than the Alde and Ore, therefore it is likely to have a lower discharge rate.

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

Watercourse	Station name	Catchment area (km^2)	Mean annual rainfall 1961-90 (mm)	Mean flow (m^3s^{-1})	Q95[1] (m^3s^{-1})	Q10[2] (m^3s^{-1})
Ore	Beversham	54.9	597	0.483	0.081	0.913
Alde	Farnham	63.9	592	0.453	0.058	0.856

[1]Q95 is the flow that is exceeded 95% of the time (i.e. low flow). [2]Q10 is the flow that is exceeded 10% of the time (i.e. high flow). Data from Centre for Ecology and Hydrology.

Contains Environment Agency information © Environment Agency and database right

Boxplots of mean daily flow record by month at the Beversham and Farnham gauging stations are presented in Figure VIII.2 and Figure VIII.3. Flows were generally higher in the winter months although during the spring there were a series of elevated flows in both the Alde and Ore. Whilst mean discharges are similar at the gauging stations on the Ore and Alde, the magnitude of peak discharge events were higher on the latter. The seasonal pattern of flows is not entirely dependent on rainfall as during the colder months there is less evaporation and transpiration, leading to a higher water table. This in turn leads to a greater level of runoff immediately after rainfall. Increased levels of runoff are likely to result in an increase in the amount of microorganisms carried into coastal waters. Additionally, higher runoff will decrease residence time in rivers, allowing contamination from more distant sources to have an increased impact during high flow events.

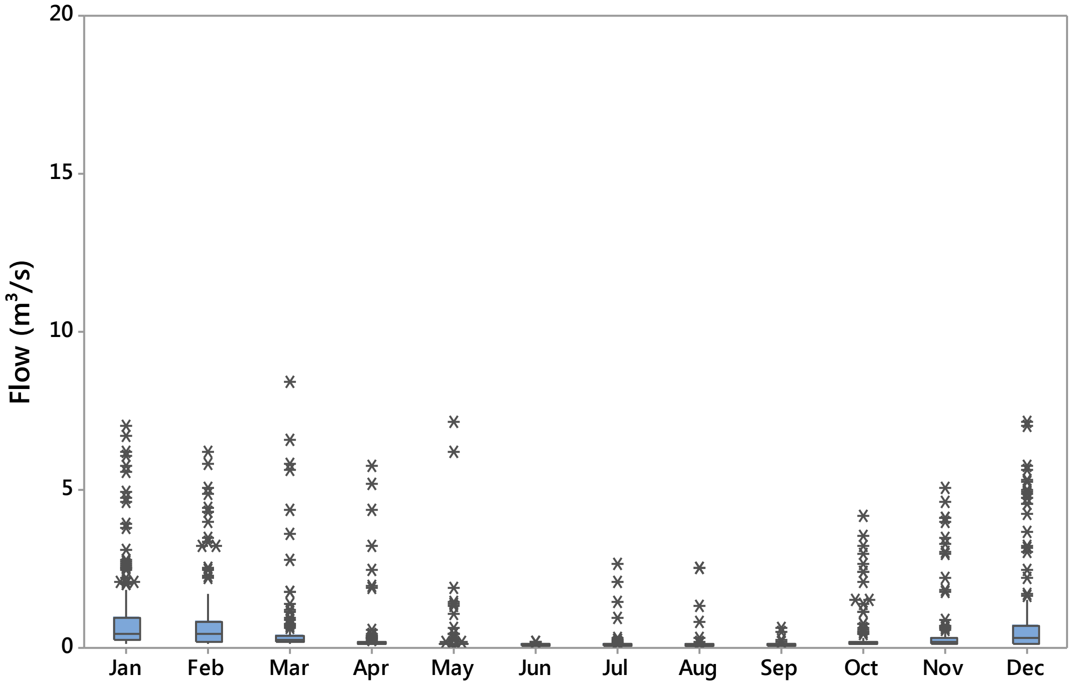


Figure VIII.2: ***Boxplots of mean daily flow records from the Beversham gauging station on the River Ore from 2010 - 2014***

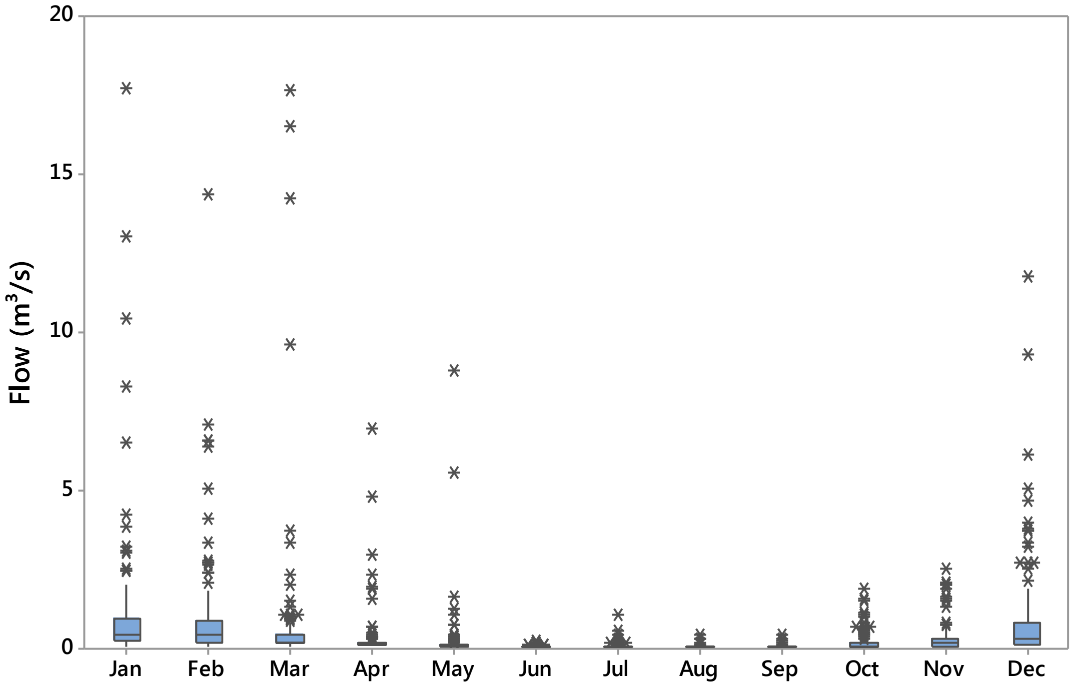


Figure VIII.3: ***Boxplots of mean daily flow records from the Farnham gauging station on the River Alde from 2010 – 2014***

A large proportion of the land bordering the estuary has been reclaimed for agriculture and is around or below sea level and is drained by a network of ditches, with the majority of the estuary perimeter enclosed by earth banks. The Iken, Sudbourne and Gedgrave pumping stations are required to drain three such areas of reclaimed land (Figure VIII.1). They have maximum capacities of 0.35, 0.5 and 0.5 m^3/s respectively (Solomon and Wright, 2012), although they will only pump for a small fraction of the time. It is likely that they operate for a much higher proportion of the time during the colder months, and during the warmer months water may be held back for irrigation of crops. The small watercourse draining the Sudbourne village area feeds into the Iken Marshes, so will ultimately drain to the estuary via the Iken pumping station.

During the shoreline survey, which was conducted under dry conditions, watercourses which could be safely accessed were sampled for *E. coli* and spot flow measurements were made. The results and locations are presented in Table VIII.2 and Figure VIII.4.

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

Ref.	Description	*E. coli* concentration (CFU/100ml)	Flow (m^3/sec)	*E. coli* loading (CFU/day)
A	Sluice outfall	110	0.124	$1.2x10^{10}$
B	Pumped outfall	90	0.012	$9.3x10^{8}$
C	Sudbourne pumping station	90	Not pumping	

Figure VIII.4: Locations of shoreline survey observations

No sizeable watercourses lie within 3 km of the shellfishery. *E. coli* loadings of three freshwater outfalls were measured. Two outfalls, one pumped and one sluiced were flowing at the time of survey and showed low flow rates (<0.2 m^3/s). These drain the Aldeburgh marshes between them. Sudbourne pumping station was not pumping at the time of the survey, but a water sample was taken from the drainage channel behind. All three outfalls had low *E. coli* concentrations ≤110 CFU/100ml and the two that were flowing had low flows and low *E. coli* loadings.

It is therefore concluded that there are six key freshwater inputs to the Alde estuary, three of which are minor rivers which all discharge to the head of the estuary (around 10 km up estuary of the shellfishery), and three of which are pumped outfalls with a relatively low pumping capacity. The geographical distribution of these suggests there may be a tendency for increasing levels of runoff borne contamination towards the upper reaches, however due to the large distance between the river discharges and the shellfishery their impacts on shellfish hygiene are likely to be minor. The pumped outfalls will operate more during the colder months of the year, and river flows will also be higher at these times.

Appendix IX. Hydrography

IX.1. Bathymetry

Figure IX.1: Bathymetry of the Alde/Ore estuary complex

The Alde/Ore is a spit enclosed estuary that has a long and narrow main channel of about 26 km from mouth to tidal limit, and is less than 300 m in width for much of its length. The main channel averages about 5 m in depth and intertidal areas are generally limited to narrow strips. It runs parallel to the coast behind a shingle bar for most of its length before heading inland and opening out into a wider, shallower tidal basin with more extensive intertidal areas. The Butley estuary forms a smaller, shallower sidearm that branches off from the main channel about 5 km from its mouth, where the channel splits around Havergate Island. Another shallow creek (Stony Ditch) emanates from the main channel at the other end of Havergate Island. Much of the surrounding land is reclaimed grazing marsh and lies behind earth banks. The fishery at Home Reach lies just up-estuary from 'The Horse' where the channel shallows to less than 2 m relative to chart datum. Tidal streams may accelerate slightly here and promote mixing of the water column. The main freshwater inputs are minor rivers which drain to the head of the estuary at Snape.

IX.2. Tides and Currents

Water circulation patterns within estuaries and coastal waters are driven by tides, which are regular and predictable, with more dynamic and unpredictable effects from freshwater inputs, barometric pressure and winds superimposed on this.

Table IX.1 Tidal levels and ranges within the Alde survey area

	Height above chart datum (m)				Range (m)	
Port	**MHWS**	**MHWN**	**MLWN**	**MLWS**	**Spring**	**Neap**
Iken Cliffs	2.9	2.4	1.1	0.6	2.3	1.3
Slaughden Quay	2.9	2.6	1.0	0.6	2.3	1.6
Orford Quay	2.8	2.3	1.1	0.6	2.2	1.2

Data from Admiralty TotalTide

The Alde/Ore estuary can be described as mesotidal, with a tidal range of 2.3 m and 1.6 m at Slaughden Quay on spring and neap tides respectively. High water arrives at Iken Cliffs just over an hour after it arrives at Orford Quay. Tidal curves at the three stations within the estuary are slightly asymmetrical, with the ebb tide lasting for about 30-40 minutes longer than the flood tide (i.e. flood dominant). There are no tidal diamonds within the estuary complex.

Tidal streams are likely to dominate patterns of circulation within the estuary, and will flow up the estuary on the flood tide and back down on the ebb. Therefore contamination from shoreline sources will travel up or down estuary with the tide, impacting either side along the same shore, and the magnitude of their impacts will decrease with increasing distance as the plume spreads. The maximum current velocity at the mouth of the Ore is reported to be 1.63 m/s (Royal Haskoning, 2009). No further firm information on current speeds or direction was found during the literature search. It was therefore not possible to make reliable estimates of the tidal excursion and hence the approximate distances over which contamination will be carried during the course of a tide. It is however possible to infer that the maximum tidal excursion is unlikely to exceed about 15 km so contamination from sources downstream of the Butley confluence are not expected to be carried as far as the fishery during the course of a flood tide.

In addition to tidally driven currents are the effects of freshwater inputs and wind. Freshwater inputs are very low relative to tidal exchange and the system as a whole is considered well mixed (Futurecoast, 2002). As such, density effects are thought unlikely to significantly modify tidal circulation patterns, although this may not necessarily apply to the upper reaches where the main freshwater inputs are located.

Repeated salinity measurements were made between 2004 and 2013 at the shellfish waters monitoring point at Home Reach (n=87). Additionally, a few salinity measurements were taken during the winter months (2011 to 2013) at four further locations in the upper estuary (n=6 to 8).

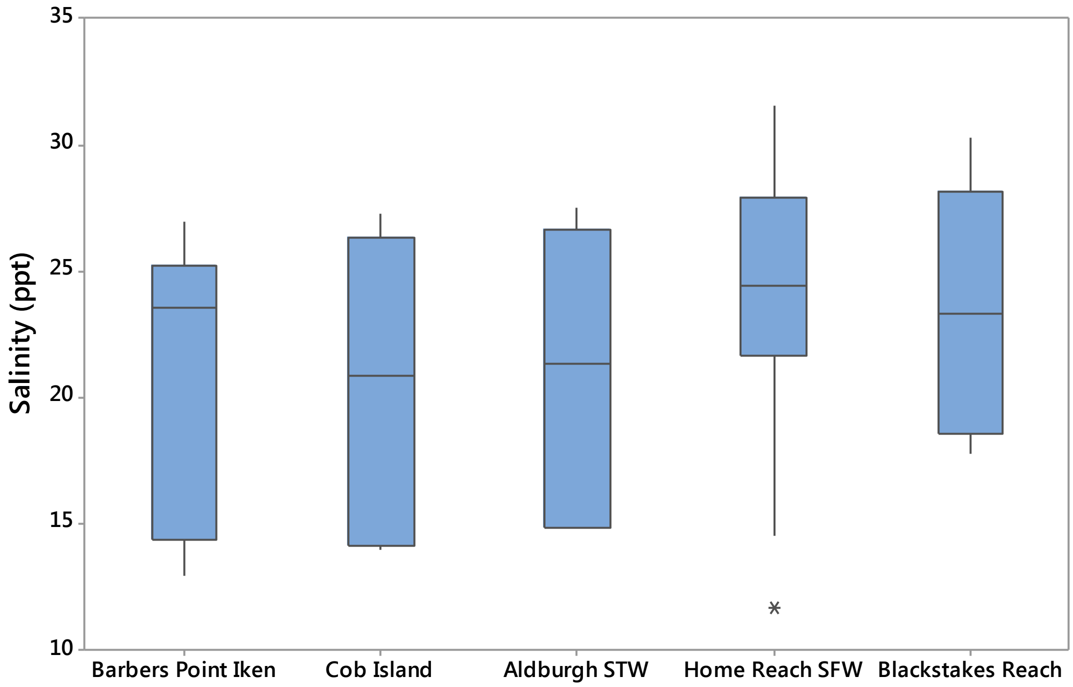


Figure IX.2: Boxplot of salinity measurements at five locations in the Alde survey area (Barbers Point, Cob Island, Aldeburgh STW, Blackstakes Reach; 2011-2013; Home Reach; 2004-2013)
Contains Environment Agency information © Environment Agency and database right

Measurements taken at Home Reach were more numerous and taken throughout the year, so the distribution of results here is not directly comparable with the other four sites. The average salinity at Home Reach was 24.4 ppt and ranged from 11.7 to 31.6 ppt. Across the other four sites, there is a gradual decrease in salinity towards the downstream end, but the gradient is very slight, with a drop in average salinity of less than 3 ppt over an 8 km stretch. These measurements indicate a significant proportion of the water in the upper estuary originates from land runoff, particularly during the winter months, and also suggests that there is the potential for density effects to occur. These would tend to manifest as a net seaward flow of less dense, fresher water at the surface, with net return flows of more saline water at depth.

Lower salinities at Home Reach were not associated with higher levels of faecal indicator bacteria in the water column (Figure X.6). This may be a consequence of the shape and in particular the length of the estuary, which will mean that freshwater is only flushed out of the upper reaches very gradually. Bacterial contamination delivered by land runoff may therefore die off much more rapidly than the runoff itself is flushed from the estuary. No firm information on the flushing characteristics of the estuary could be found to confirm this however.

Strong winds will modify surface currents. Winds typically drive surface water at about 3% of the wind speed (Brown, 1991) so a gale force wind (34 knots or 17.2 m/s) would drive surface water currents of about 0.5 m/s. These create return currents which may travel lower in the water column or along sheltered margins. The prevailing south westerly winds will tend to push surface water up the estuary in the vicinity of the fishery, but will have the opposite effect upstream of the sharp bend at Slaughden. 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. Where these waves break contamination held in intertidal sediments may be re-suspended, although given the enclosed nature of the estuary strong wave action is not generally anticipated.

Appendix X. Microbiological Data: Seawater

Summary statistics and geographical variation

There is one shellfish water, originally designated under Directive 2006/113/EC (European Communities, 2006) and a Protected Area under Directive 2000/60/EC (European Communities, 2000), relevant to the Alde production area. Figure X.1 shows the location of this site. Table X.1 presents summary statistics for bacteriological monitoring results and Figure X.2 presents a boxplot of faecal coliform levels from the monitoring point.

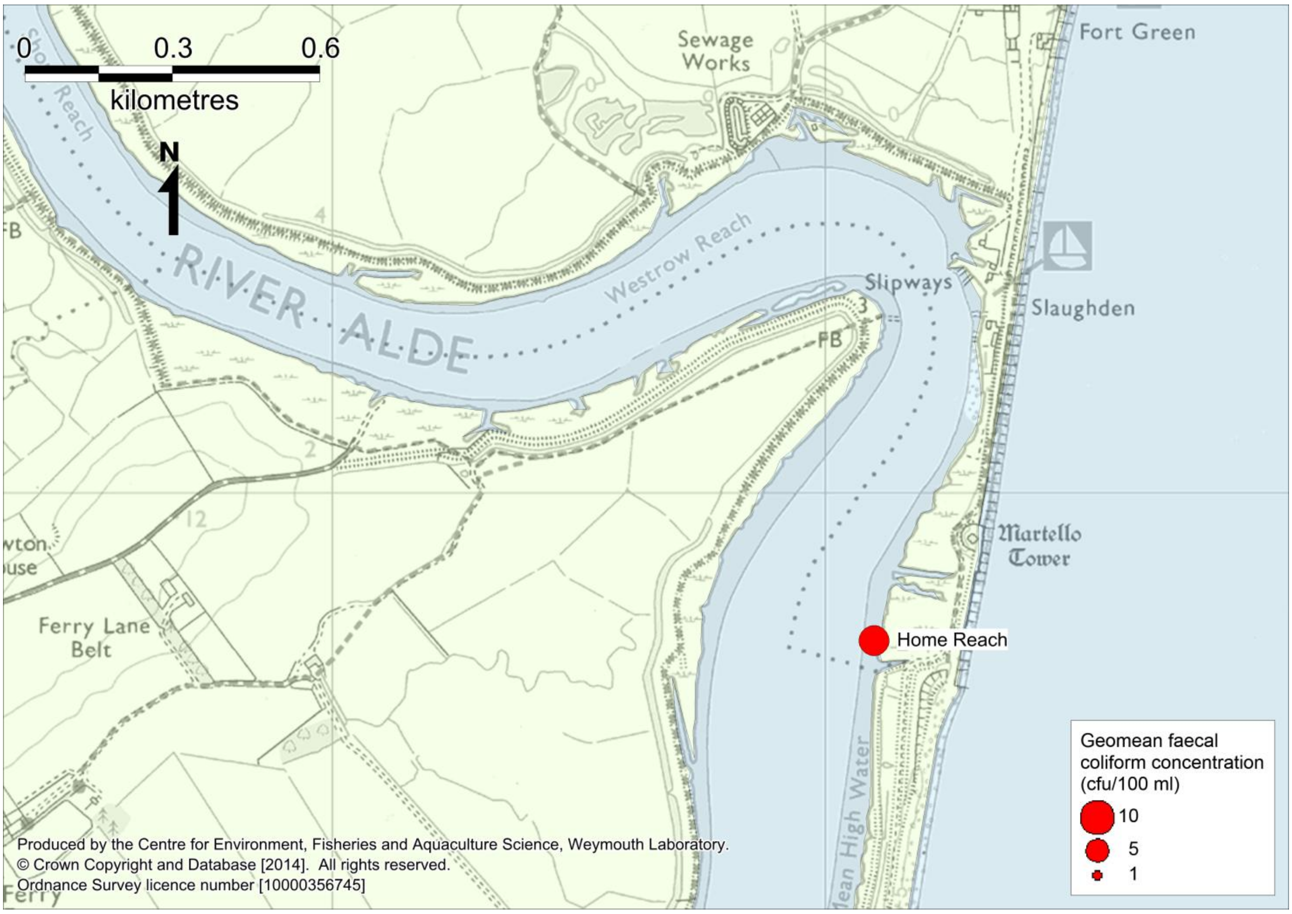


Figure X.1: Location of designated shellfish water monitoring point.

Contains Environment Agency information © Environment Agency and database right

Table X.1: Summary statistics for shellfish waters faecal coliform results, 2004 to 2013 (cfu/100ml).

Site	No.	Date of first sample	Date of last sample	Geometric mean	Min.	Max.	% over 100	% over 1,000
Home Reach	43	27/01/2004	23/07/2013	8.3	<2	144	9.3	0.0

Contains Environment Agency information © Environment Agency and database right

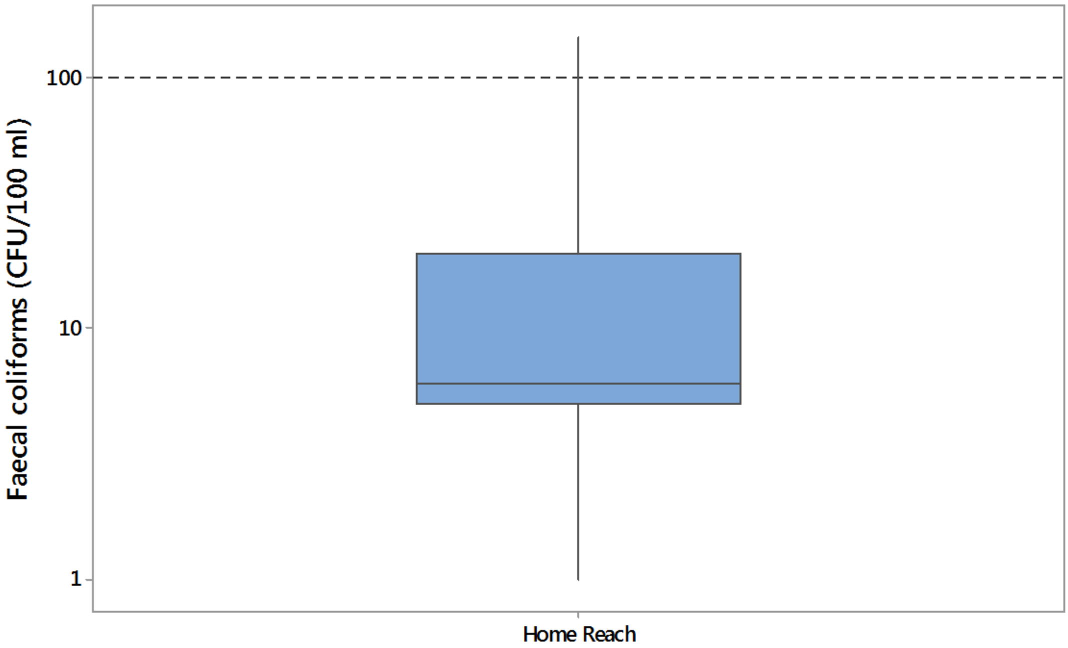


Figure X.2: Box-and-whisker plots of all faecal coliforms results
Contains Environment Agency information © Environment Agency and database right

Levels of faecal coliforms in the water column here were fairly consistent, with few results exceeding 100 cfu/100ml and a maximum result of 144 cfu/100ml.

Overall temporal pattern in results

The overall variation in faecal coliform levels found at the shellfish water site over time is shown in Figure X.3.

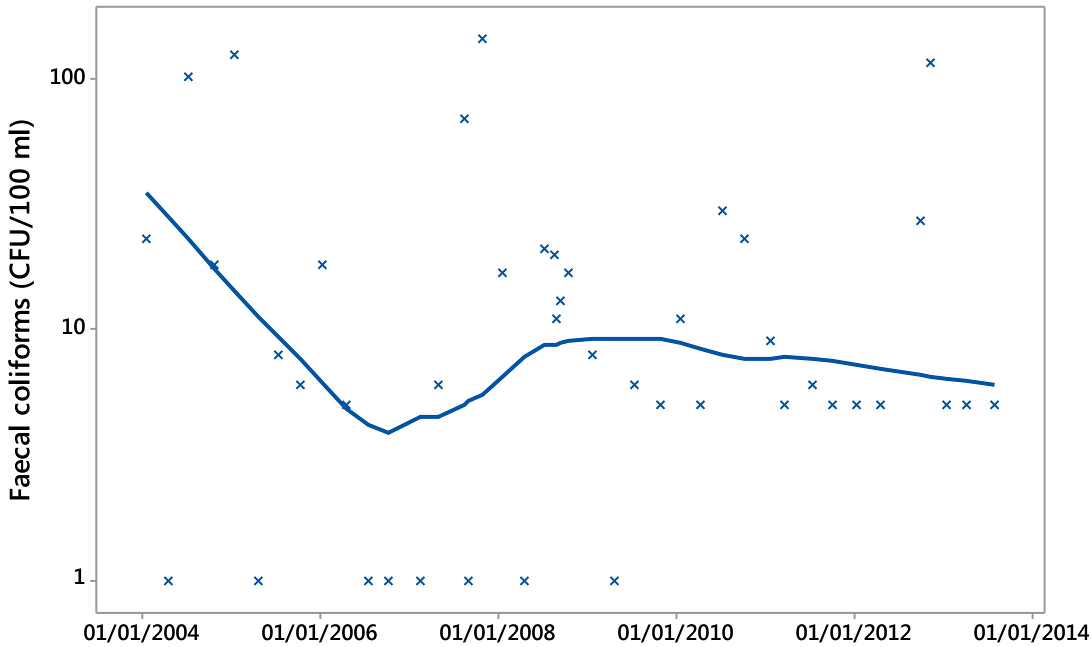


Figure X.3: Scatterplot of faecal coliform results by date, overlaid with loess lines
Contains Environment Agency information © Environment Agency and database right

Figure X.3appears to show a decline in faecal coliform levels at Home Reach between 2004 and mid-2013. However, the Loess line is misleading as its method of calculation resulted in a strong emphasis being placed on a small number of high results at the start of the period, and there was little change in average faecal coliform concentrations throughout. In 2010 it appears that the threshold for faecal coliform detection in sample testing methodology increased from two to 10 cfu/100 ml.

Seasonal patterns of results

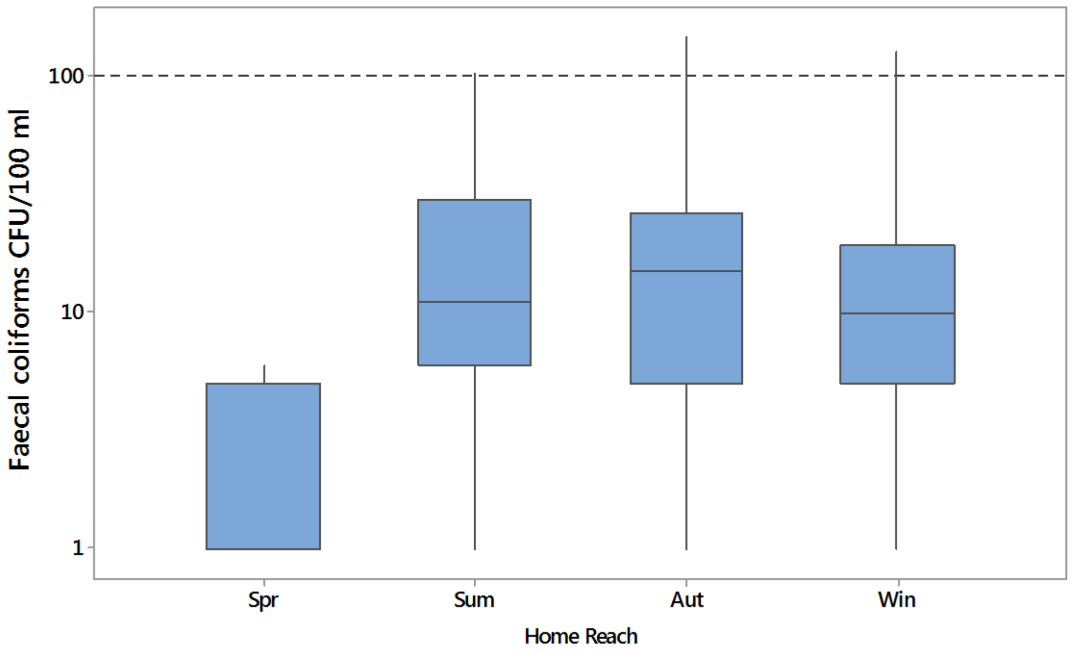


Figure X.4: Boxplot of faecal coliform results by site and season
Contains Environment Agency information © Environment Agency and database right

One-way ANOVA tests showed that there were significant variations in faecal coliform levels between seasons (p=0.028). Post ANOVA Tukey tests showed that faecal coliform concentrations were significantly lower in spring than in summer.

Influence of tide

To investigate the effects of tidal state on faecal coliform results, circular-linear correlations were carried out against both the high/low and spring/neap tidal cycles for each of these shellfish waters sampling points. Correlation coefficients are presented in Table X.2, with statistically significant correlations highlighted in yellow.

Table X.2: Circular linear correlation coefficients (r) and associated p values for faecal coliform results against the high low and spring/neap tidal cycles

	High/low tides		Spring/neap tides	
Site Name	**r**	**p**	**r**	**p**
Home Reach	0.289	0.035	0.234	0.112

Contains Environment Agency information © Environment Agency and database right

Figure X.5 presents a polar plot of log_{10} faecal coliform results against tidal states on the high/low cycle. High water at Aldeburgh is at 0° and low water is at 180°. Results of 100 faecal coliforms/100ml or less are plotted in green, those exceeding 100 are plotted in yellow.

Figure X.5: Polar plots of $\log_{10}$ faecal coliforms against tidal state on the high/low tidal cycle for the shellfish water monitoring point with significant correlations
Contains Environment Agency information © Environment Agency and database right

Faecal coliform concentrations tended to be higher on average towards the end of the ebb tide, suggesting upstream sources are an influence.

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 Woodbridge weather station (Appendix VI for details) over various periods running up to sample collection and faecal coliform results. These are presented in Table X.3 and statistically significant correlations ($p<0.05$) are highlighted in yellow. Rainfall records were only available from 2010 onwards so sample numbers are small.

Table X.3: Spearmans Rank correlation coefficients for faecal coliform results against recent rainfall

	Site	**Home Reach**
	n	**15**
24 hour periods prior to sampling	1 day	0.362
	2 days	0.455
	3 days	0.248
	4 days	0.204
	5 days	0.172
	6 days	0.170
	7 days	0.361
Total prior to sampling over	2 days	0.464
	3 days	0.673
	4 days	0.642
	5 days	0.689
	6 days	0.680
	7 days	0.699

Contains Environment Agency information © Environment Agency and database right

Faecal coliform concentrations increased significantly two days after a rainfall event. After two days rainfall the effect was no longer significant, but the low numbers of samples and consistent influence of cumulative totals suggest that if further results were considered that the influence of rainfall events may be more prolonged.

Influence of salinity

Salinity was recorded on most sampling occasions. Figure X.6 shows a scatter-plot of faecal coliforms against salinity. A Pearson's correlation was undertaken to determine whether there was a statistically significant effect of salinity on faecal coliforms.

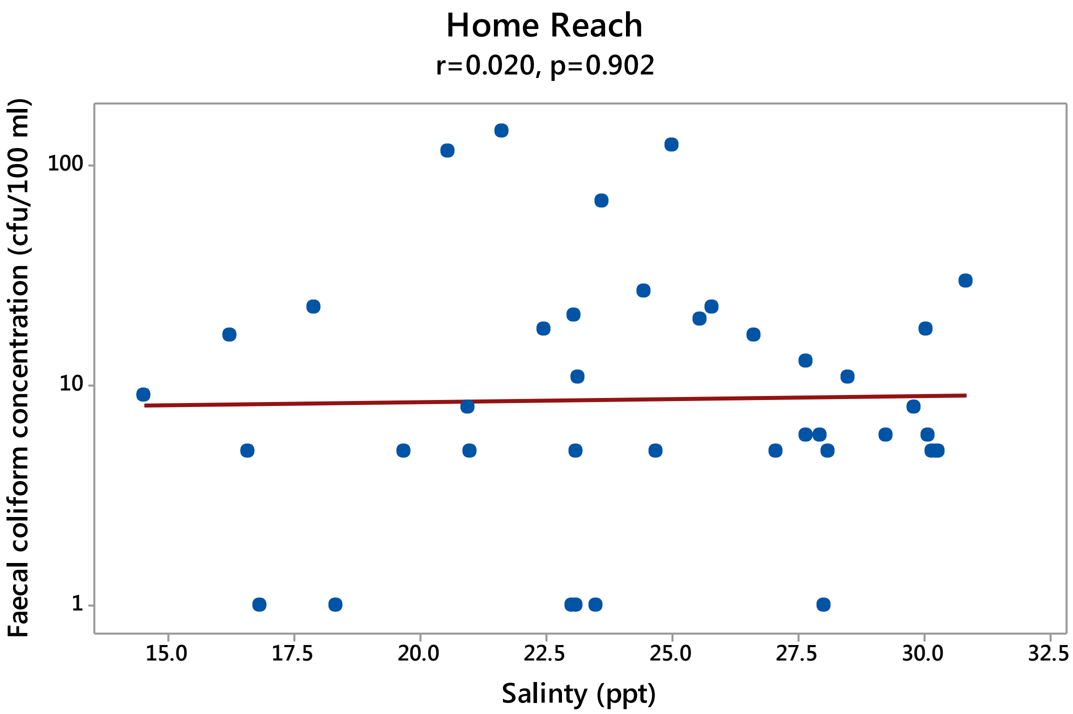


Figure X.6: Scatter-plot of salinity against faecal coliforms.
Contains Environment Agency information © Environment Agency and database right

There was no significant correlation between faecal coliform levels and salinity at Home Reach, and Figure X.6 suggests that results were random with respect to salinity.

Appendix XI. Microbiological Data: Shellfish Flesh

XI.1. Summary statistics and geographical variation

There are four shellfish hygiene RMPs which have been sampled between 2004 and 2014, three of which are for mussels and one for Pacific oysters. The geometric mean results of shellfish flesh monitoring from 2004 to 2014 at these RMPs are presented in Figure XI.1. Summary statistics are presented in Table XI.1 and boxplots for mussel and pacific oyster RMPs are shown in Figure XI.2 and Figure XI.3.

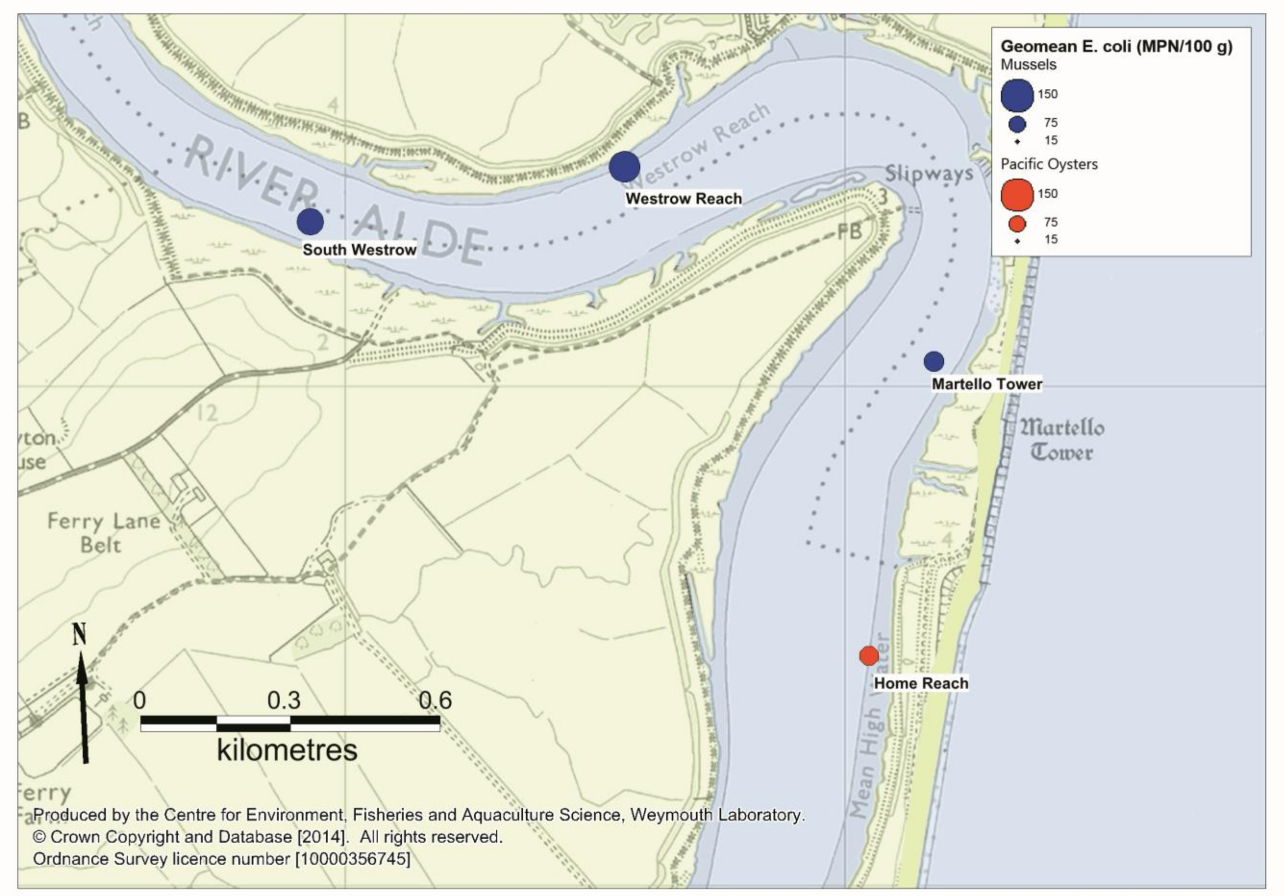


Figure XI.1: Bivalve RMPs active since 2004

Table XI.1: Summary statistics of *E. coli* results (MPN/100 g) sampled from2004 onwards

RMP	Species	No.	Date of first sample	Date of last sample	Geometric mean	Min.	Max.	% over 230	% over 4600
South Westrow	Mussels	45	26/01/2004	12/12/2007	119.0	<20	3,500	24.4	0.0
Westrow Reach	Mussels	25	19/01/2004	17/12/2008	140.0	<20	5,400	28.0	4.0
Martello Tower	Mussels	21	19/01/2004	10/10/2005	92.8	<20	1,300	23.8	0.0
Home Reach	Pacific oysters	99	19/01/2004	09/06/2014	89.5	<20	>18,000	21.2	3.0

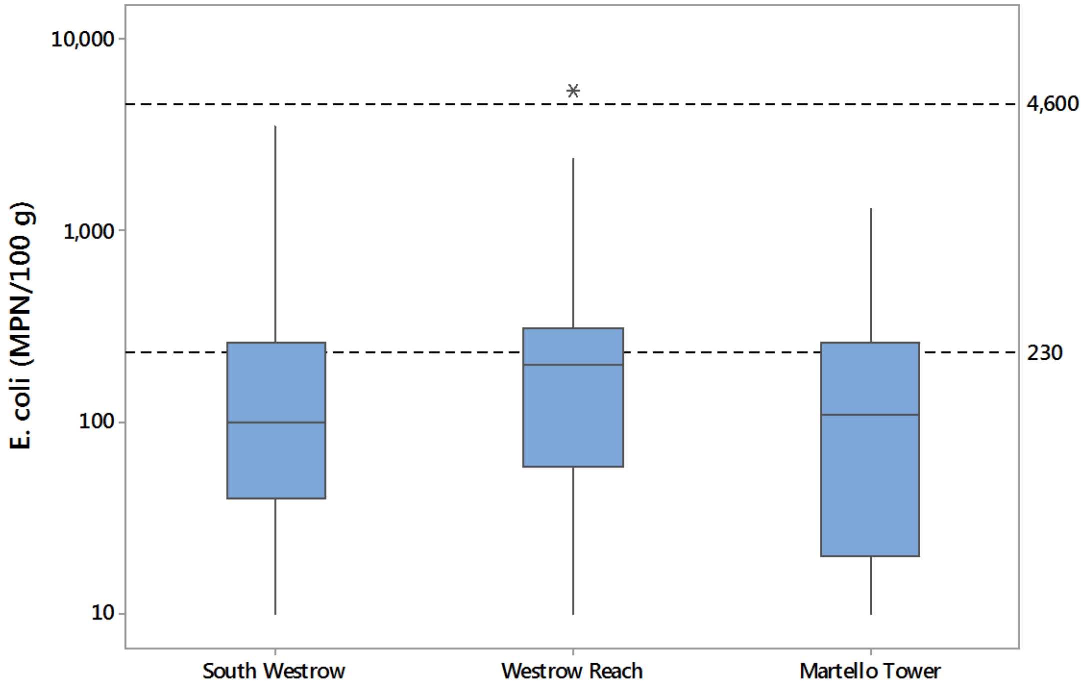


Figure XI.2: Boxplots of *E. coli* results from mussel RMPs from 2004 onwards.

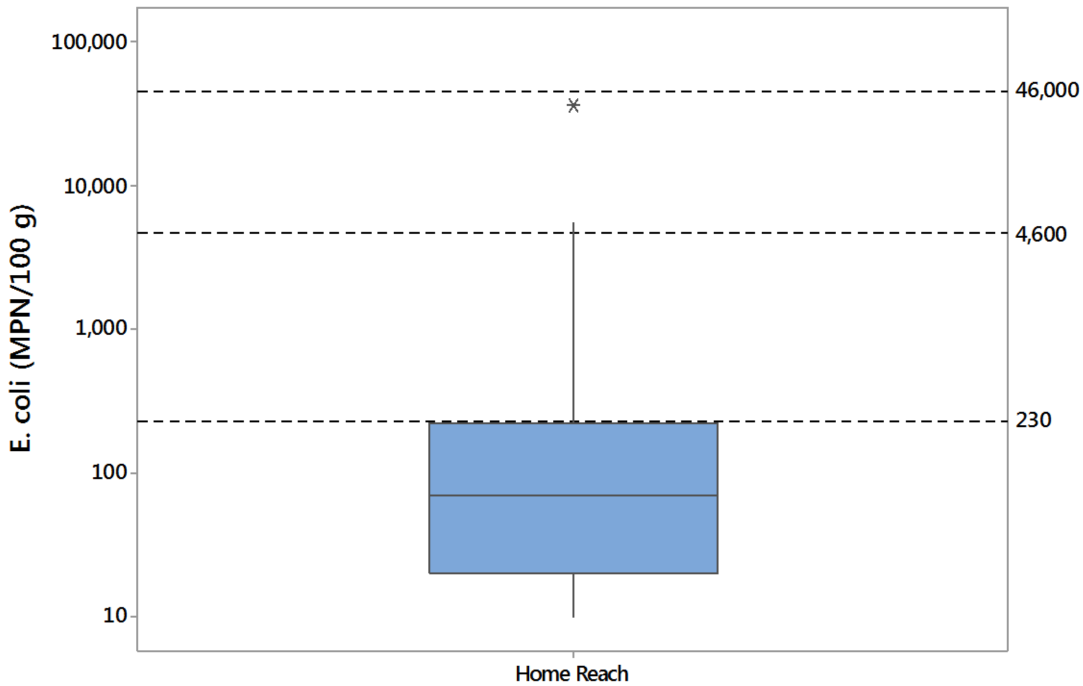


Figure XI.3: Boxplots of *E. coli* results from the Pacific oyster RMP from 2004 onwards.

A large proportion of results at all four RMPs were less than 230 *E. coli* MPN/100g, and results at all were consistent with a solid B classification. Across the three mussel RMPs, results were higher on average at Westrow Reach, and this was the only RMP where results exceeding 4600 *E. coli* MPN/100g. Statistical comparisons of average *E. coli* levels at the three mussel RMPs revealed that there were no significant differences between them (one-way ANOVA, p=0.628). Pearson's correlations were undertaken to compare *E.* coli levels between mussel RMPs which were sampled on the same day and therefore under similar environmental conditions on 15 or more occasions. Results were strongly correlated between all mussel site pairings (r=0.665 or greater, p=0.007 or less) suggesting that they share similar contaminating influences.

XI.2. Overall temporal pattern in results

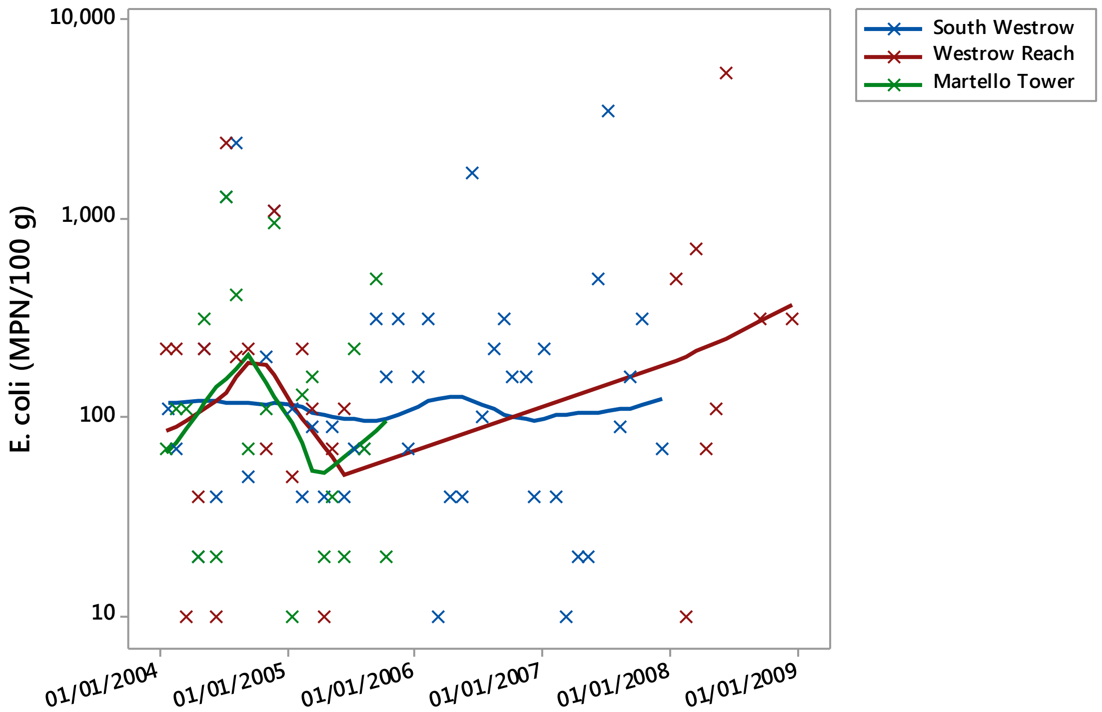


Figure XI.4: Scatterplot of *E. coli* results in mussels by RMP and date, overlaid with loess lines

Figure XI.4 shows that overall levels of *E. coli* in mussels remained about the same between 2004 and 2008 at South Westrow. At Martello Tower and Westrow Reach there were insufficient data to determine any trends.

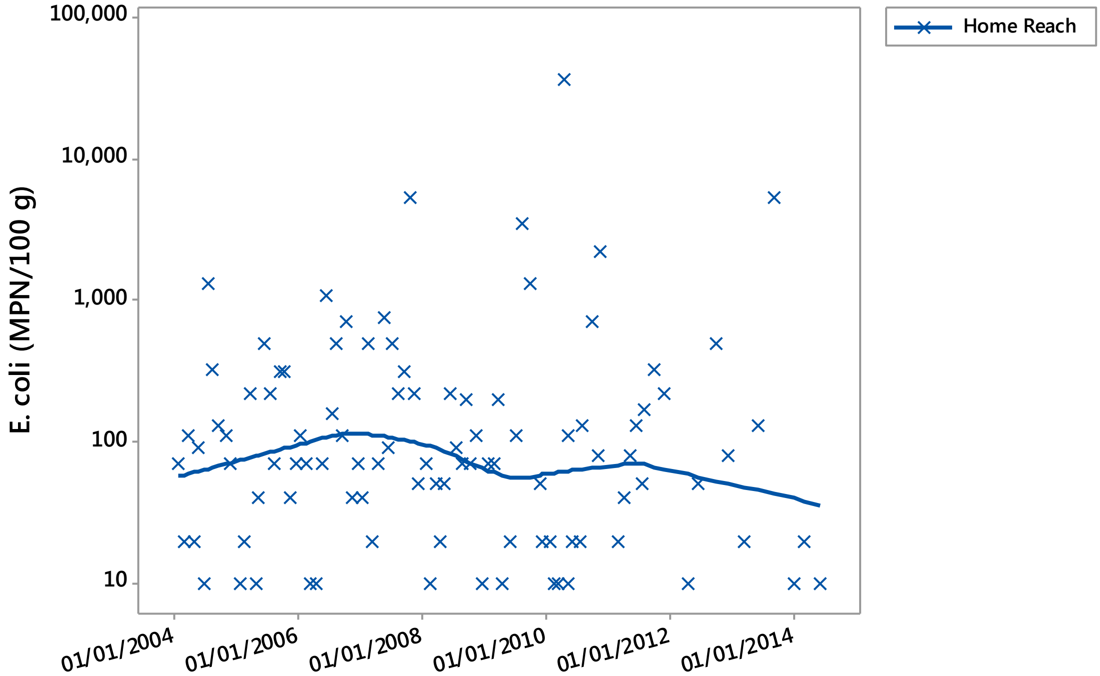


Figure XI.5: Scatterplot of *E. coli* results in Pacific oysters by RMP and date, overlaid with loess lines

Figure XI.5 shows that *E. coli* levels in Pacific oysters have remained fairly constant since 2004 at Home Reach.

XI.3. Seasonal patterns of results

The seasonal patterns of results from 2004 onwards were investigated by RMP (Figure XI.6. and Figure XI.7).

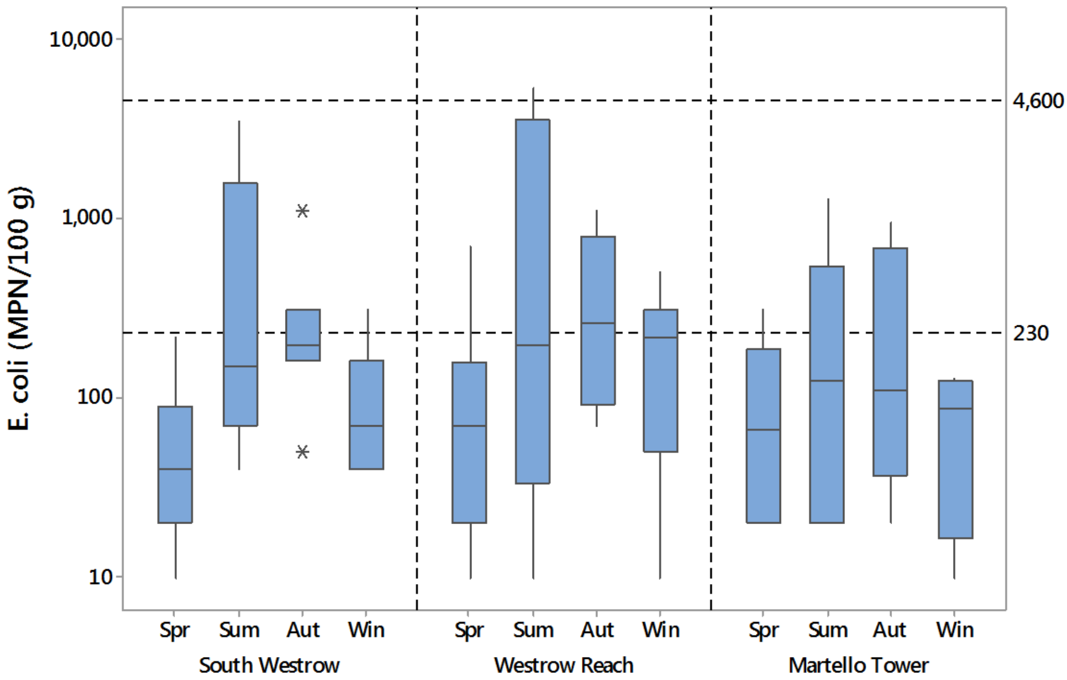


Figure XI.6: Boxplot of *E. coli* results in mussels by RMP and season

One-way ANOVA tests showed that there was significant seasonal variation in *E.* coli levels at South Westrow (p<0.001). Post ANOVA testing (Tukey's comparison) identified that summer and autumn had significantly higher levels of *E. coli* at this site than the spring. There was no significant seasonal variation at Westrow Reach (p=0.339) or Martello Tower (p=0.669).

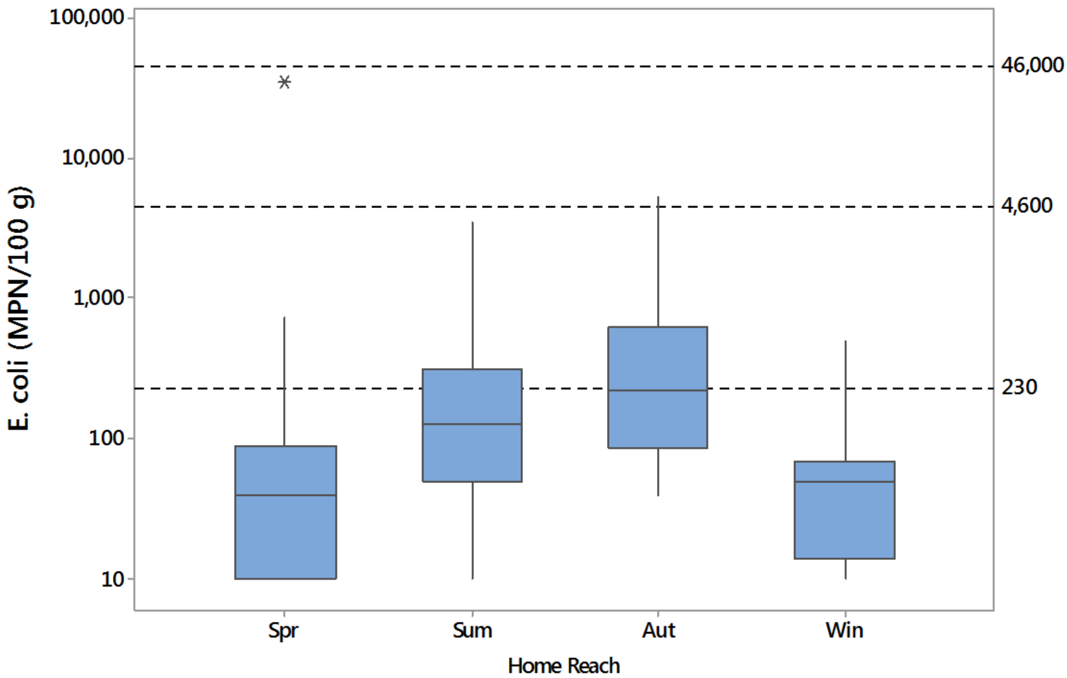


Figure XI.7: Boxplot of *E. coli* results in Pacific oysters by RMP and season

Significant variation in *E. coli* levels between seasons was found in Pacific oysters at Home Reach (one-way ANOVA, p<0.001). Post ANOVA testing (Tukey's comparison) indicated that *E. coli* levels were significantly higher in the autumn compared to the spring and winter and *E. coli* levels in the summer were significantly higher than in the winter.

XI.4. Influence of tide

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

Table XI.2: Circular linear correlation coefficients (r) and associated p values for *E. coli* results from RMPs in the Alde production area against the high/low and spring/neap tidal cycles at Aldeburgh

Site Name	Species	n	High/low tides		Spring/neap tides	
			r	p	r	p
South Westrow	Mussels	45	0.186	0.233	0.181	0.251
Westrow Reach	Mussels	25	0.134	0.672	0.127	0.703
Martello Tower	Mussels	21	0.173	0.584	0.234	0.372
Home Reach	Pacific oysters	99	0.253	0.002	0.239	0.004

A statistically significant influence of both tidal cycles on results was found at Home Reach. Figure XI.8 presents a polar plot of $\log_{10}$ *E. coli* results against tidal state on the high/low cycle at this RMP. High water at Aldeburgh 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 4,600 are plotted in yellow, and those exceeding 4,600 are plotted in red.

Figure XI.8: Polar plot of $\log_{10}$ *E. coli* results (MPN/100g) against tidal state on the high/low tidal cycle for Home Reach

Whilst results were similar across the high/low tidal cycles on average, all results exceeding 4600 *E. coli* MPN/100g arose during the second half of the flood tide. Also, there was an absence of very low results around low water.

Figure XI.9 presents a polar plot of $\log_{10}$ *E. coli* results against the spring/neap tidal cycle for Home Reach. 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 4,600 are plotted in yellow, and those exceeding 4600 are plotted in red.

Figure XI.9: Polar plots of log_{10} *E. coli* results (MPN/100g) against tidal state on spring/neap cycle for Home Reach

Results were similar on average across the spring/neap tidal cycle, but were marginally higher around spring tides, and the results exceeding 4600 *E. coli* MPN/100g all occurred shortly after spring tides.

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 Benhill weather station (Appendix VI for details) over various periods running up to sample collection. These are presented in Table XI.3 and statistically significant correlations ($p<0.05$) are highlighted in yellow.

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

Site		**Home Reach**
Species		**Pacific oyster**
n		**29**
24 hour periods prior to sampling	1 day	-0.127
	2 days	0.030
	3 days	-0.023
	4 days	-0.002
	5 days	-0.185
	6 days	0.055
	7 days	0.126
Total prior to sampling over	2 days	-0.067
	3 days	-0.108
	4 days	-0.117
	5 days	-0.098
	6 days	-0.093
	7 days	-0.074

Rainfall data was only available from 2010 onwards. Nevertheless, there was sufficient data to clearly indicate that antecedent rainfall has no influence on *E. coli* levels in Pacific oysters at Home Reach.

Appendix XII. Shoreline Survey Report

Date (time): 03/06/2014 (08:00 – 12:30)

04/06/2014 (08:30 – 12:30)

Cefas Officer: Alastair Cook

Local Enforcement Authority Officer: Harry Tice (Suffolk Coastal DC).

Area surveyed: Orford to Aldeburgh (Figure XII.1).

Weather: 03/06/2014 dry, 16°C, wind W force 2.

04/06/2014 overcast, 12°C, wind S force 3.

Tides:

Admiralty Totaltide predictions for Orford Quay. All times in this report are BST.

03/06/2014	04/06/2014
High 04:25 2.6 m	High 05:05 2.5 m
High 16:42 2.6 m	High 17:24 2.5 m
Low 10:27 0.9 m	Low 11:05 1.0 m
Low 23:05 0.7 m	Low 23:46 0.8 m

Objectives:

The shoreline survey aims to obtain samples of freshwater inputs to the area for bacteriological testing; confirm the location of previously identified sources of potential contamination; locate other potential sources of contamination that were previously unknown, and ascertain information on the status of the fishery. A full list of recorded observations is presented in Table XII.1and the locations of these observations are mapped in Figure XII.1. Although numerous photographs were taken during the survey, the previous user of the camera had encrypted the memory card so none of the photographs was retrievable.

XII.1. Fishery

The fishery is a small Pacific oyster farm which is not currently active due to ill health of the harvester. Formerly, relatively small volumes of Pacific oysters were ongrown from seed to a market size in mesh bags hung between wooden posts and sold to local markets. The only stock present is a very limited amount of mature oysters which are held for sampling purposes. It has been temporarily declassified for around two years. Whether the site will be restocked in the future is uncertain.

XII.2. Sources of contamination

Sewage discharges

No sewage discharges to the estuary were seen, although a sewage pumping station was observed in Aldeburgh (observation 10).

Freshwater inputs

Observed freshwater inputs were limited to a gravity sluice and a smaller floating pump draining the Aldeburgh Marshes, and the Sudbourne pumping station between Aldeburgh and Orford. The latter was not in operation at the time of the survey. Water samples were taken from all, and none were carrying high levels of *E. coli* at the time (maximum of 110 cfu/100ml).

Boats and Shipping

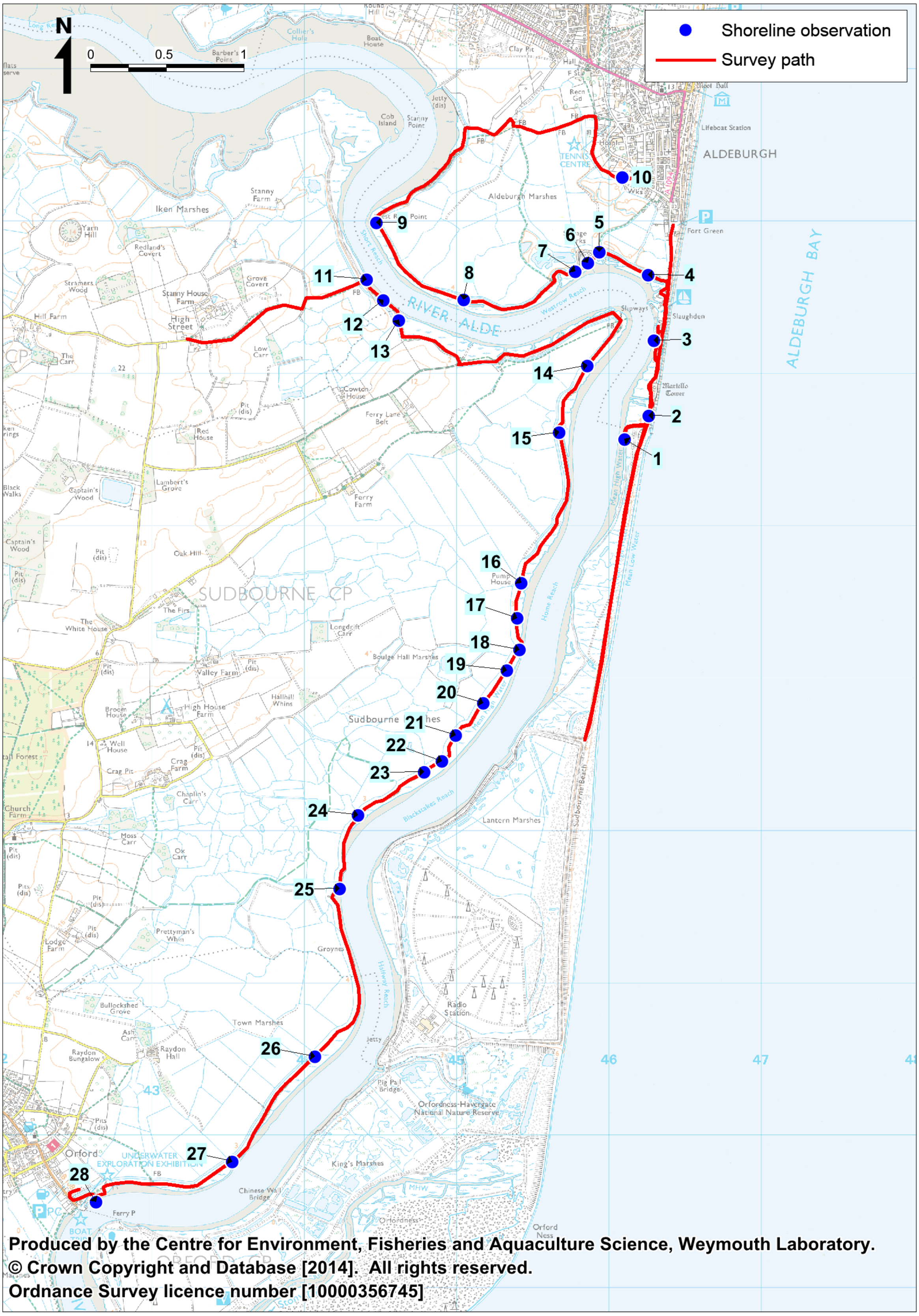
There were numerous yachts on moorings in the Aldeburgh area and in the Orford area. At least four of the yachts seen at Aldeburgh were occupied.

Livestock

Numerous grazing livestock were recorded on the Aldeburgh Marshes and the Sudbourne Marshes. These were generally fenced off from accessing the shoreline. In one place just north of Orford, a small area of saltmarsh had obviously been recently accessed by cattle.

Wildlife

No major aggregations of wildlife were observed.



© Crown Copyright and Database [2014]. All rights reserved.
Ordnance Survey licence number [10000356745]

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

Table XII.1: Details of Shoreline Observations

No	Time and Date	NGR	Observation
1	03/06/2014 09:22	TM 46100 54568	South end of trestle site. North end at creek.
2	03/06/2014 09:41	TM 46259 54723	About 30 yachts on moorings, including at least 4 with people in residence
3	03/06/2014 09:50	TM 46293 55216	Water sample 1 (seawater)
4	03/06/2014 10:04	TM 46254 55649	About 100 boats on moorings
5	03/06/2014 10:10	TM 45934 55800	47 cattle in field
6	03/06/2014 10:13	TM 45857 55726	Corporation sluice (gravity sluice). Flowing 150cmx20cmx0.412m/s. Water sample 2.
7	03/06/2014 10:23	TM 45774 55671	13 cattle in field
8	03/06/2014 10:40	TM 45044 55484	Fulcher Sluice (completely silted up)
9	03/06/2014 10:55	TM 44469 55992	Pumped outfall (floating pump on marsh drain). 80cmx5cmx0.3m/s. Water sample 3.
10	03/06/2014 11:44	TM 46084 56290	Sewage pumping station.
11	04/06/2014 08:46	TM 44407 55617	Water sample 4 (seawater)
12	04/06/2014 08:51	TM 44516 55483	120 sheep in field
13	04/06/2014 08:54	TM 44618 55349	Barge and yachts on moorings
14	04/06/2014 09:24	TM 45854 55053	Sheep droppings on seawall, electric fence preventing access to shore.
15	04/06/2014 09:31	TM 45671 54613	18 horses in field.
16	04/06/2014 09:46	TM 45421 53626	Sudbourne Pumping Station (not pumping). Water sample 5 taken from drain on landward side. 2 sheep.
17	04/06/2014 09:58	TM 45393 53394	One large sheep.
18	04/06/2014 10:01	TM 45408 53188	Sluice (silted up and inoperable).
19	04/06/2014 10:03	TM 45326 53053	75 sheep in field.
20	04/06/2014 10:07	TM 45170 52838	About 200 sheep in field.
21	04/06/2014 10:11	TM 44991 52627	140 sheep in field
22	04/06/2014 10:13	TM 44900 52457	17 sheep on sea wall, electric fence preventing access to shore.
23	04/06/2014 10:16	TM 44784 52386	20 cattle in field
24	04/06/2014 10:23	TM 44351 52100	25 cattle in field
25	04/06/2014 10:35	TM 44227 51620	37 cattle in field. Sluice (silted up and inoperable)
26	04/06/2014 10:52	TM 44068 50517	Evidence of cattle on saltmarsh here (footprints, dung)
27	04/06/2014 11:05	TM 43524 49828	12 cattle (can access shore). Start of numerous yacht moorings extending past Orford.
28	04/06/2014 11:21	TM 42630 49564	Water sample 6 (seawater).

Produced by the Centre for Environment, Fisheries and Aquaculture Science, Weymouth Laboratory.
© Crown Copyright and Database [2014]. All rights reserved.
Ordnance Survey licence number [10000356745]

Figure XII.2: Water sample results

Table XII.2: Water sample *E. coli* results and spot flow gauging results

No.	Date and time	NGR	Description	*E. coli* (cfu/100ml)	Discharge (m^3/sec)	Bacterial loading (*E. coli*/day)
1	03/06/2014 09:50	TM 46293 55216	Seawater	40		
2	03/06/2014 10:13	TM 45857 55726	Freshwater (sluice outfall)	110	0.1236	$1.2x10^{10}$
3	03/06/2014 10:55	TM 44469 55992	Freshwater (pumped outfall)	90	0.012	$9.3x10^{8}$
4	04/06/2014 08:46	TM 44407 55617	Seawater	<10		
5	04/06/2014 09:46	TM 45421 53626	Freshwater (pumping station)	90	Not pumping	
6	04/06/2014 11:21	TM 42630 49564	Seawater	<10		

References

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

Austin, G.E., Read, W.J., Calbrade, N.A., Mellan, H.J., Musgrove, A.J., Skellorn, W., Hearn, R.D., Stroud, D.A., Wotton, S.R., and Holt, C.A., 2014. Waterbirds in the UK 2011/12: The Wetland Bird Survey. BTO/RSPB/JNCC. Thetford.

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

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

Environment Agency, 2009. Essex, Suffolk and Norfolk shellfish water scoping study. Report by Enviros Consulting Ltd, April 2009.

Environment Agency, 2013. East Suffolk Abstraction Licensing Strategy, February 2013.

EU Working Group on the Microbiological Monitoring of Bivalve Harvest Areas, 2014. Microbiological Monitoring of Bivalve Harvest Areas. Guide to Good Practice: Technical Application. Issue 5, June 2014.

European Communities, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the filed of water policy, Official Journal the European Communities 22.12.2000 L327:1-72.

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.

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

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

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

Kay, D, Crowther, J., Stapleton, C.M., Wyler, M.D., Fewtrell, L., Anthony, S.G., Bradford, M., Edwards, A., Francis, C.A., Hopkins, M. Kay, C., McDonald, A.T., Watkins, J., Wilkinson, J., 2008a. Faecal indicator organism concentrations and catchment export coefficients in the UK. Water Research 42: 2649–2661.

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

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

Lees, D.N., 2000 Viruses in bivalve shellfish. Int. J. Food. Microbiol. 59: 81-116.

Mackintosh, D., 2013, Orford, Available at: http://www.ports.org.uk/port.asp?id=65 Accessed January 2014

MCS, 2012. 2012. Alde Ore Estuary recommended MCZ. Seasearch Site Surveys 2012.

Melton Hall website, 2014. Information page on river cruises. http://meltonhall.co.uk/local-attractions/boat-trips. Accessed August 2014.

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

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

MMO, 2011. Bradwell Site, Barrier Wall Impact Assessment. Section 9. Marine Ecology.

MMO, 2014. UK vessel lists 2014. April 2014. http://www.marinemanagement.org.uk/fisheries/statistics/vessel.htm Accessed: April 2014.

NERC, 2012. UK gauging station network. Available at: http://www.ceh.ac.uk/data/nrfa/uk_gauging_station_network.html

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

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

Royal Haskoning, 2009. Lowestoft Ness to Landguard Point SMP2. Final Report. Appendix I – Estuaries Assessment. June 2009.

RSPB, 2013. Havergate Island. Available at: http://www.rspb.org.uk/reserves/guide/h/havergate/about.aspx Accessed January 2014

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.

Solomon, D. J., Wright, R., 2012. Prioritising pumping stations for facilities for the passage of eels and other fish. Final Report (v1.2) to the Environment Agency, September 2012

Suffolk Wildlife Trust, 2012. Ecological Assessment Hinterland of the Alde and Ore Estuaries 2010-2012

The Green Blue, 2010. Pump Out Directory. Available at: http://www.thegreenblue.org.uk/pump_out_directory.aspx. August 2013Younger, A.D., Lee, R.J., Lees, D.N. 2003. Microbiological monitoring of bivalve mollusc harvesting areas in England and Wales: rationale and approach. In: Villalba, A., Reguera, B., Romalde, J. L., Beiras, R. (eds). Molluscan Shellfish Safety. Consellería de Pesca e Asuntos Marítimos de Xunta de Galicia and Intergovernmental Oceanographic Commission of UNESCO, Santiago de Compostela, Spain. pp. 265−277.

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.
Loess	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

Harry Tice (Suffolk Coastal District Council), John Daniels (Environment Agency), Ron Jessop (Eastern IFCA).