EC Regulation 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SANITARY SURVEY REPORT

Deben Estuary

2011

Cover photo: Shore of Deben estuary at Girlings Hard.

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

CONSULTATION:

Consultee	Date of consultation	Date of response
Environment Agency	26/01/2012	17/05/2012
Local Enforcement Authority	26/01/2012	15/02/2012
Anglian Water	10/05/2012	26/05/2012

DISSEMINATION: Food Standards Agency, Suffolk Coastal District Council, Environment Agency, Anglian Water.

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CONTENTS

1. INTRODUCTION

1.1 LEGISLATIVE REQUIREMENT

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

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

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

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

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

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

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

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

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

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

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

In addition to better targeting the location of RMPs and frequency of sampling for microbiological monitoring, it is believed that the sanitary survey may serve to help to target future water quality improvements and improve analysis of their effects on the BMPA. 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 information relevant to undertake a sanitary survey for wild and cultured Pacific oysters (*Crassostrea gigas*), wild mussels (*Mytilus* spp.), wild cockles (*Cerastoderma edule*) and cultured native oysters (*Ostrea edulis*) within the Deben estuary.

1.2 SITE DESCRIPTION

DEBEN ESTUARY

The Deben estuary is situated on the Suffolk Coast in the east of England (Figure 1.1). The fishery lies in the middle reaches of the estuary, between Ramsholt and Waldringfield.

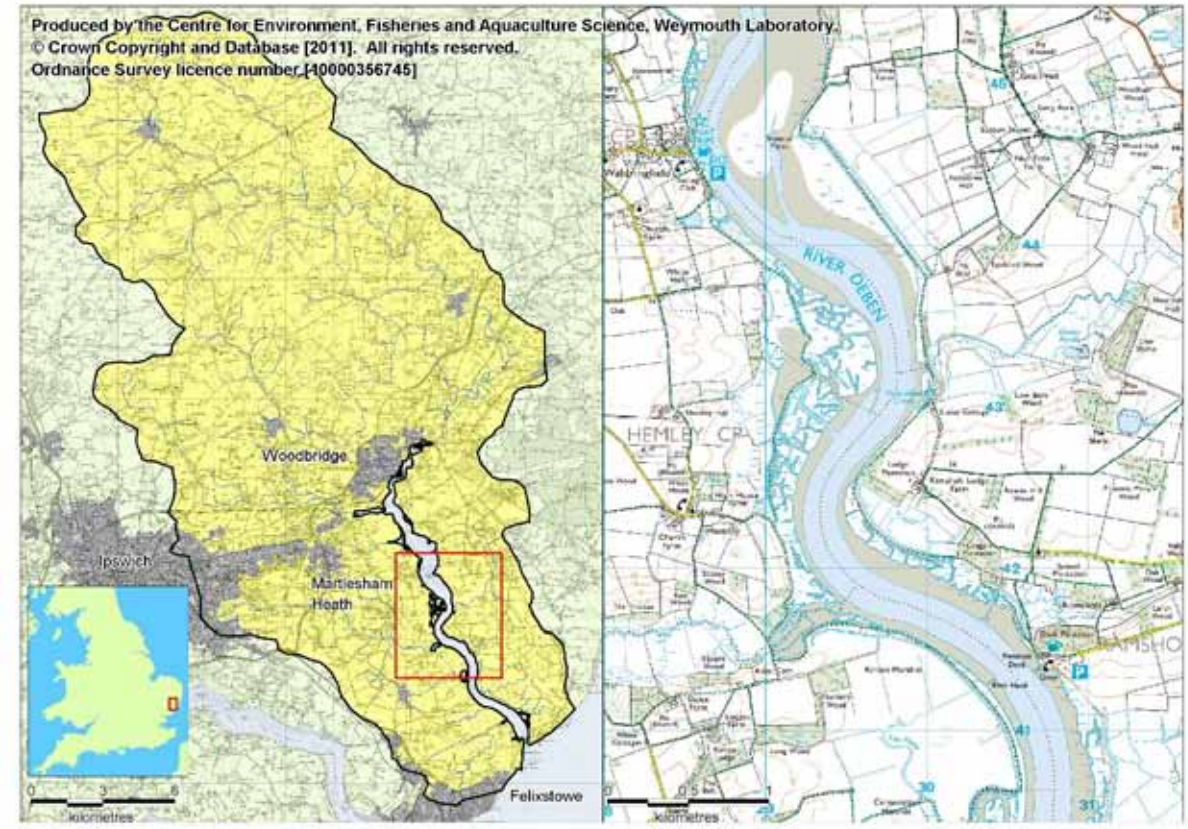

Figure 1.1 Location of the Deben Estuary and its river catchments

The estuary has a north-south orientation and is approximately 12 km in length from its mouth at Felixstowe Ferry to its tidal limit at Melton. It consists of a relatively narrow meandering channel flanked by intertidal mud flats and saltmarsh, with flood embankments lining its lower reaches and at Woodbridge. The surrounding land is mainly low lying arable farmland, some of which is reclaimed saltmarsh, with scattered farms and small settlements. The town of Woodbridge lies at the head of the estuary. The estuary is used by yachtsmen and wildfowlers, and a few small commercial fishing vessels operate from Felixstowe Ferry.

CATCHMENT

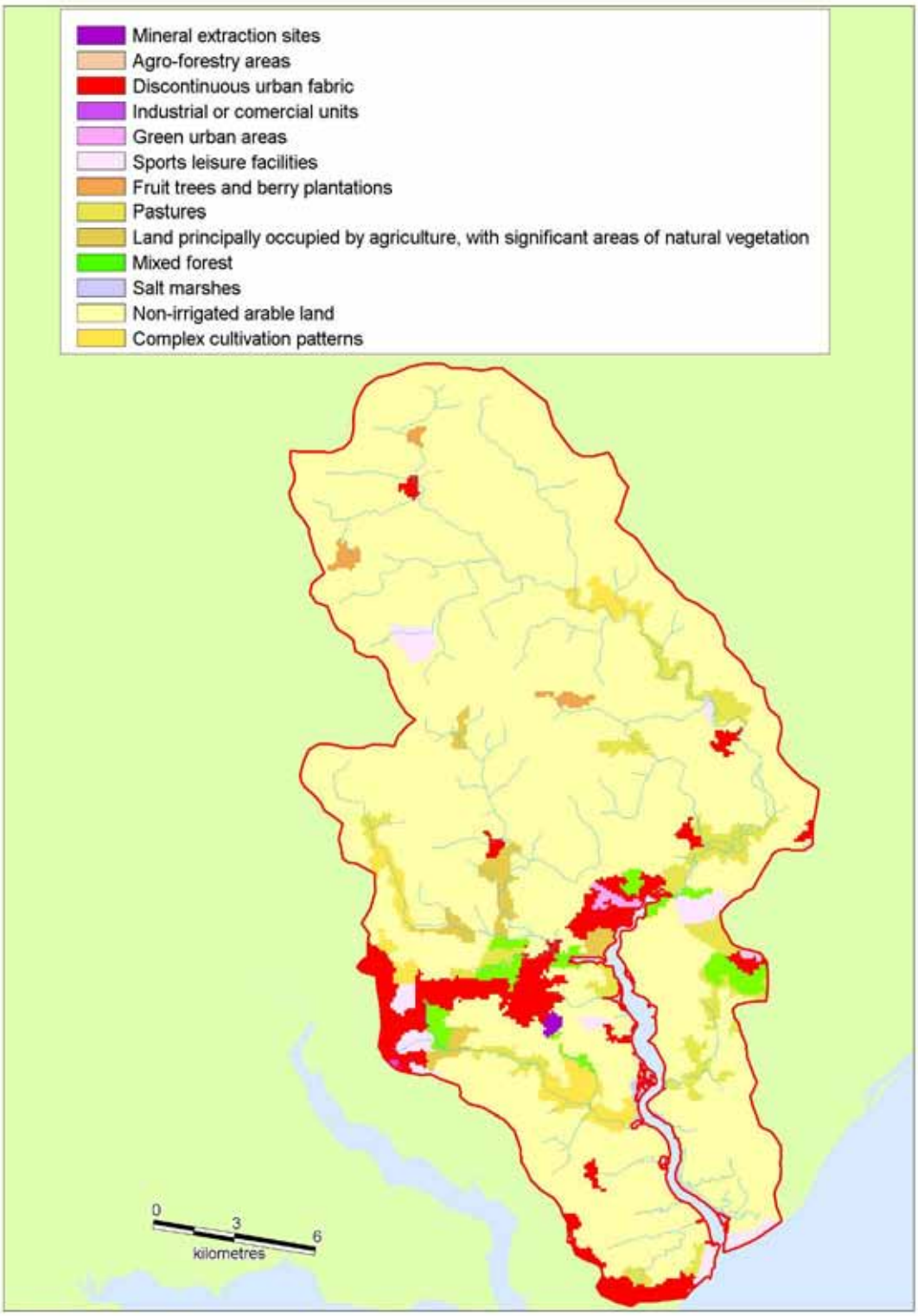

Figure 1.2 Land cover within the Deben Estuary catchment.
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http://www.eea.europa.eu

The Deben estuary drains a catchment area of about 395km^2. The largest freshwater input is the River Deben, but there are also several smaller

watercourses draining to the estuary. The majority of the catchment area is used for arable farming, with the main urban areas at the head of the estuary. Small areas of pasture are present, and these tend to be found adjacent to watercourses. The catchment is low lying, with a maximum altitude of 65.5m AOD, and soils are a mixture of moderate and high permeability (NERC, 2011a).

2. SHELLFISHERIES

This sanitary survey of the Deben estuary was prompted by an application to harvest wild and cultured Pacific oysters, wild mussels and wild cockles within a small area of the middle reaches of this estuary. The following description is based on information recorded during the shoreline survey and a 'Statement of Intent' subsequently provided by the harvester.

2.1 SPECIES, LOCATION AND EXTENT

Pacific oysters have been naturally occurring within the Deben estuary for more than a decade, possibly as a legacy of an oyster farm which operated in Spinny Creek throughout the 1980s and 1990s. The oysters require a hard substrate (such as gravel or mussel bed) to settle on, and do not survive on the soft mud that covers much of the intertidal area within the Deben estuary, so their distribution within the estuary is somewhat limited, and they tend to co-occur with mussels.

Concentrations of up to 4 oysters per m^2 were observed at Girlings Hard during the shoreline survey on a mixed substrate of sand, gravel, mussels and mud. A range of sizes were observed suggesting regular spatfalls occur. Subsequent to the shoreline survey, a more thorough assessment of Pacific oyster stocks was carried out at Girlings Hard, as part of negotiations with Natural England concerning the development of this fishery. From counts of Pacific oysters within 40 randomly selected quadrats the standing stock here was estimated to be in the very approximate order of 12 tonnes. Therefore the amount of natural stock present here is probably too small to sustain commercial scale harvesting over a prolonged period, but some of these stocks will be harvested and sold on once the area is classified.

Occasional specimens of Pacific oysters were observed during the shoreline survey on mussel beds off The Hams, about 2.5 km upstream from Girlings Hard, and mussel beds where Pacific oysters were likely to be present were seen at Stonner Point about 1km upstream of the fishery. It is possible that there are significant oyster stocks below the low water mark within the main estuary channel, but a dredge would be required to harvest them. The stock status outside of Girlings Hard was not investigated in detail during the shoreline survey as the harvester had not requested their classification at that time.

Subsequent to the shoreline survey applications were received to extend the classifications on the east bank from Girlings Hard up to a track just north of Stonner Point and also down past the mouth of Shottisham Creek. The former request was to allow the harvest of wild stocks from the extended area, and the latter was to allow the hardening and short term storage of stocks in a convenient and accessible location immediately prior to harvest.

The main intention in the longer term is to develop an oyster farm, but these plans are in an early stage of development. Pacific oysters will be ongrown in suspended net bags within Spinny Creek, either from hatchery seed or natural

stock collected from the estuary. A trial is planned shortly to establish the most suitable culture system, after which production will be ramped up. Approval from Natural England for the establishment of the oyster farm is pending. An oyster culture site may also be developed on Girlings Hard at some point in the future, and this area will be used for short term storage of bags of oysters before they are relocated to Spinny Creek. A further aim in the long term is to culture native oysters on Girlings Hard. Native oysters were formerly present in the estuary, but have not been harvested commercially since the 1930s.

Classification of the naturally occurring mussel beds on the east bank at Girlings hard and in the area up to Stonner Point has also been requested. Additional mussel beds were observed during the shoreline survey to the north of this but these do not require classification.

There are some wild cockles present at Girlings Hard and possibly in other areas of the Deben estuary. The harvester estimates an annual production of around 8 tonnes may be possible and has requested that Girlings Hard be classified for this species.

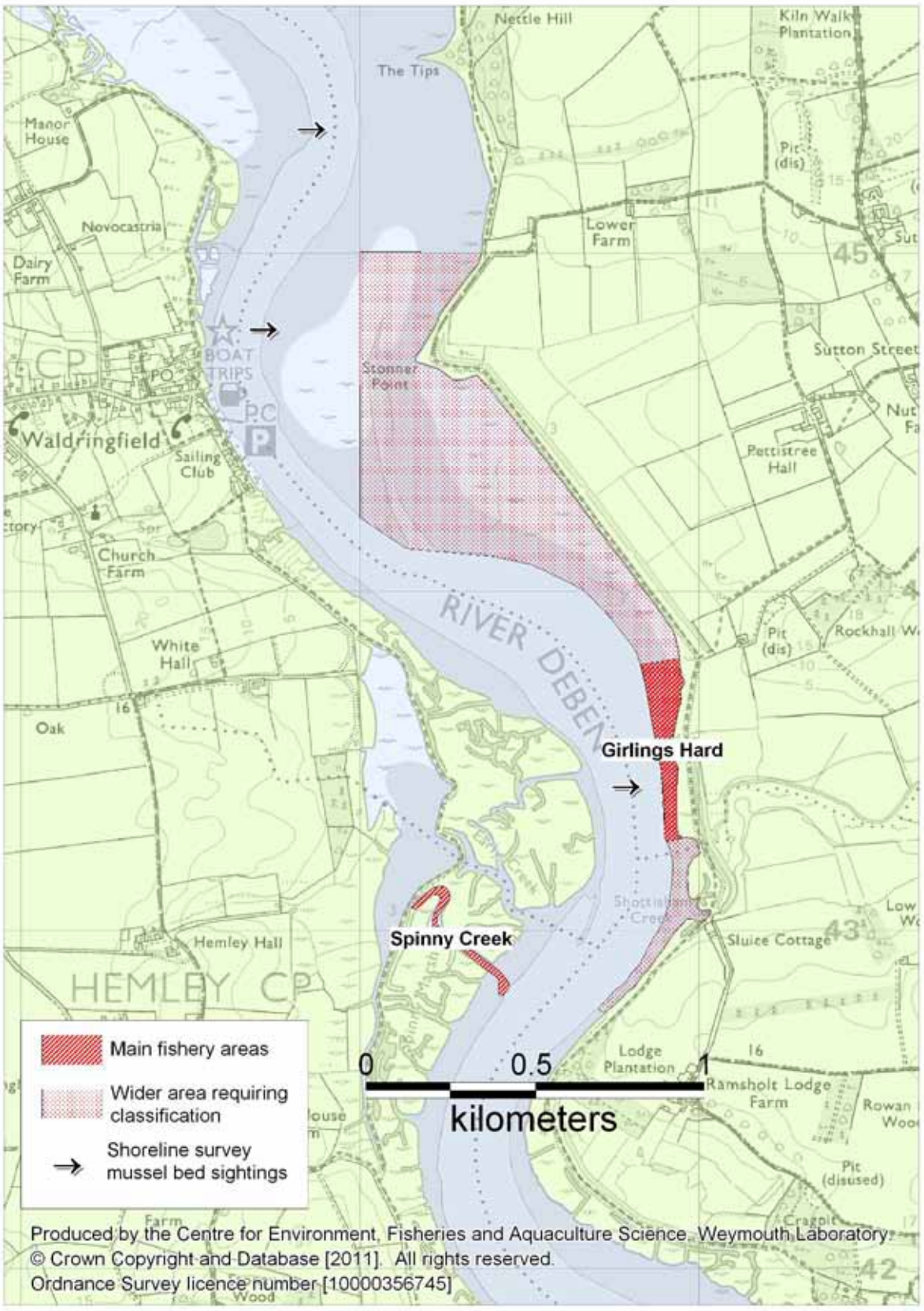

Figure 2.1 Location of fishery within the Deben estuary.

2.2 GROWING METHODS AND HARVESTING TECHNIQUES

Within Spinny Creek Pacific oysters will be cultured in mesh bags suspended from floats. This is preferred to on bottom culture due to the soft mud, within which oysters would not survive. Trials are planned for the near future to establish the most appropriate configuration of the culture system. Once the results of these trials have been evaluated, the site will be fully developed. Naturally occurring stock from around the estuary will be used in the trials. Once the fishery is more developed, either diploid or triploid hatchery stock will be used. In the first instance half or three quarter grown oysters will be ongrown to help establish the business, but in the longer term hatchery seed of about 8mm will be grown to market size over 3-4 years.

At some point once the Pacific oyster farm is established, the culture of native oysters on Girlings Hard may be attempted, either on trestles or in bags laid on the shore. The mussel and cockle stocks are wild. Harvesting of all stocks will be by hand. The grower does not intend to use a dredge or divers to access stocks below the low water line.

2.3 SEASONALITY OF HARVEST, CONSERVATION CONTROLS AND DEVELOPMENT POTENTIAL

Harvest of both mussels and oysters may occur at any time of the year, although it is possible that the oysters are in relatively poor (post spawning) condition during the summer. No conservation controls apply to any of these fisheries apart from a minimum landing size of 50mm for mussels. The use of dredges for the capture of bivalve molluscs within the Deben estuary would require authorisation from the Eastern Inshore Fisheries and Conservation Authority according to their byelaws.

The oyster farm required approval from Natural England through the 'Appropriate Assessment' process under the requirements of the EC Habitats Directive (EC, 1992). Approval is to be granted, but subject to the condition that the oyster farm will not increase the amount of reproductively active Pacific oysters within the estuary. The removal of naturally occurring stocks will be taken into consideration, allowing the importation of the same amount of (diploid) hatchery seed, and the use of (sterile) triploid hatchery stock is planned. There are however some uncertainties about the availability of hatchery triploids, and how they will perform within the Deben.

Naturally occurring stocks of Pacific oysters are not large enough to support sustained harvesting on a commercial scale. The initial trials of culture systems within Spinny Creek are to use between 10,000 and 50,000 oysters. The long term aim is to produce about 100,000 oysters per year. The area within Spinny Creek is about 1Ha, so a considerable amount of stock could potentially be held here. The applicant intends to establish a depuration plant so live products can be sold direct to markets. It is uncertain how the long-term aim of culturing native oysters at Girlings Hard will develop.

3. OVERALL ASSESSMENT

AIM

This section presents an overall assessment of the impacts of pollution sources on the microbiological contamination of shellfish sites within the Deben estuary as a result of a sanitary survey undertaken by Cefas on behalf of the Food Standards Agency. Its main purpose is to inform the sampling plan for the microbiological monitoring and classification of the bivalve mollusc sites within this geographical area. More detailed supporting information is presented within the Appendices.

SHELLFISHERIES

The area requiring classification for Pacific oysters includes Spinny Creek, and the intertidal area extending from Girlings Hard to just north of Stonner Point. The same area, excluding Spinny Creek, will require classification for the harvest of mussels. Girlings Hard requires classification for cockles. At some point in the future, the grower intends to attempt the culture of native oysters at Girlings Hard, but this is unlikely to occur for several years.

Pacific oyster culture in floating bags is planned within Spinny Creek. These may either be from hatchery seed, or ongrown from naturally occurring stock transplanted from the east bank. Naturally occurring Pacific oysters will be harvested from the main concentrations at Girlings Hard, and from a wider area of the east bank extending north to about 400m past Stonner Point. Classification is also required for a small area to the south of Girlings Hard, which is a convenient and accessible location to store stock immediately prior to harvest. The grower is in the process of establishing depuration facilities.

A bacteriological survey has now been completed to evaluate spatial differences in levels of *E. coli* in Pacific oysters at Girlings Hard and Spinny Marsh, the area for which the original application requested classification. A provisional B classification has been awarded for these areas on the basis of the bacteriological survey results. Additional sampling will be necessary to extend the area further to the north and south, as it is likely that levels of contamination will increase towards the head of the estuary and there may be a small hotspot of contamination by the mouth of Shottsham Creek.

POLLUTION SOURCES

FRESHWATER INPUTS

A large proportion of the freshwater inputs to the estuary are towards its head, where the Rivers Deben, Fynn and Lark discharge. There are also several smaller watercourses entering at intervals down its length. Shottisham Creek discharges to the east shore immediately south of Girlings Hard, and a small surface water outfall from an area of reclaimed farmland about 200m to the north of Girlings Hard. Kirton Creek discharges to the west shore about 1km south of Spinny Creek. There are no freshwater inputs at the head of Spinny

Creek. Overall, the total mean discharge of these is in the approximate order of 2m^3/sec. Average and peak flows are considerably higher from November to March. The majority of the catchment area drained by these watercourses is arable farmland, to which manures may be applied at certain times of the year. There is also a significant built up area at Woodbridge, and some small pockets of pasture bordering some of the watercourses which may potentially generate more highly contaminated runoff.

Therefore it is concluded that the greatest impacts from land runoff may be anticipated towards the head of the estuary, although some smaller watercourses may have localised impacts where they discharge, notably Shottisham Creek on the east bank just south of Girlings Hard, and Kirton Creek on the west bank about 1km south of Spinny Creek. Discharge volumes will be significantly higher during the winter months, although this does not necessarily mean higher loadings of *E. coli* will be carried into the estuary at these times.

AGRICULTURE

Within the Deben estuary catchment area the majority of land is used for arable agriculture. Agricultural census data indicates that most of the livestock farmed in the area are pigs or poultry, both of which are generally reared indoors. Manure and dirty water from these is collected, stored, and then strategically applied to local arable land. Therefore, widespread application of manure to arable farmland is anticipated throughout the catchment area, although the timing and exact locations of these applications is uncertain. It is possible that sewage sludge is applied to arable fields, but no records of this are held by the Environment Agency.

Some sheep and cattle are also grazed within the catchment, although not in great numbers. Land cover maps indicate that pockets of pasture flank the River Deben, with some adjacent to Shottisham Creek, Kirton Creek and the Fynn/Lark. More animals will be on pastures during the warmer months of the year, as stock levels are highest at these times. Cattle may be housed indoors during the winter, during which manures will be collected and subsequently spread on arable lands or pastures. On the pastures adjacent to Shottisham Creek it is reported that about 20 cattle are grazed from spring through to autumn.

Contamination from agricultural sources will generally be carried into the estuary watercourses, and the flux of this will be dependent on rainfall, which does not vary much between the seasons, although river discharge does is generally higher during the winter. Most, if not all watercourses discharging to the Deben estuary will be subject to contamination from livestock, either via direct deposition via grazers onto pastures, or from the spread of manures from intensive livestock units onto arable land. Manure spreading may occur at any time of the year depending on crop cycles. Direct deposition on pastures is likely to be highest in the summer. In spatial terms, the largest proportion of agricultural inputs will be carried into the estuary via the River Deben and the Fynn/Lark, so highest levels of contamination may be expected towards the top

of the estuary. Contamination from cattle grazing from spring to autumn on pastures adjacent to Shottisham Creek may be a significant local source which would be expected to impact most heavily at the south end of the Girlings Hard site.

HUMAN POPULATION

Population densities are highest around the head of the estuary, within the town of Woodbridge and the eastern outskirts of Ipswich. Most of the rest of the catchment area is sparsely populated, although the small town of Felixstowe Ferry lies at the mouth. Tourism is a significant industry in the area. Therefore, depending on the configuration of the sewerage networks, highest inputs from human sewage are likely to occur in the vicinity of Woodbridge, and the volumes discharged are likely to be higher during the summer tourist season.

SEWAGE DISCHARGES

The two main continuous sewage outfalls in the area are both located in the vicinity of Woodbridge. There are also a series of smaller continuous discharges to the River Deben, and the Fynn/Lark, as well as one to Kirton Stream (Falkenham Creek) and one to Marsh Drain (Queens Fleet), down estuary from the fishery. None of these discharges are subject to tertiary treatment, so their effluent will contain significant concentrations of *E. coli*. A similar spatial profile is seen for intermittent overflow discharges associated with these sewerage networks. It was not possible to draw any conclusions in terms of spill frequencies and volumes from these as the telemetry only records high levels rather than an actual spill. There are a few small private discharges within the Shottisham Creek and Falkenham Creek catchment areas, but the majority of these also lie within the River Deben and Fynn/Lark catchments.

The vast majority of sewage is discharged up estuary from the fishery, so increasing levels of contamination towards Woodbridge are anticipated. At times of high rainfall, it is possible that some of the overflow discharges operate, and most of these will impact towards the head of the estuary. Therefore, on this basis, RMPs should be set at the northern boundaries of any classified zones. Kirton STW may be of some impact to the Spinny Creek site, and a small number of private discharges to Shottisham Creek and Kirton Creek are likely to contribute to levels of *E. coli* within these watercourses.

BOATS

The estuary is popular with resident and visiting yachts, and overboard discharges of untreated sewage are likely to be made regularly here, mainly during the summer months. There are significant areas of swinging moorings in relatively close proximity to the fishery at Ramsholt, about 2.5km south of Girlings Hard, and at Waldringfield, but there are a few moorings and anchorages between these two locations. It is likely that overboard discharges are also made by vessels on passage. Therefore, the fishery is likely to be impacted by overboard discharges from boats, with a higher occurrence of these likely around the moorings in Waldringfield. There will be a strong

seasonality to these impacts, which are anticipated to be negligible during the winter and potentially quite significant to the fishery during the summer.

WILDLIFE

The Deben estuary is flanked by significant areas of saltmarsh and mud flats, which support significant populations of overwintering wildfowl and waders. Over 17,000 birds of these overwintered in the Deben estuary in 2006/7. Therefore some impacts may be expected from birds, particularly waders which are likely forage in very close proximity to the fishery. Lower numbers of waterbirds and seabirds will be present throughout the rest of the year. Spatially, any impacts are likely to be diffuse and unpredictable. It is likely that occasional seals visit the estuary from time to time, but there are no major breeding colonies nearby. Therefore, impacts from seals are likely to be minor at most, and will not be predictable either spatially or temporally.

SUMMARY OF POLLUTION SOURCES

An overview of sources of pollution likely to affect the levels of microbiological contamination at the fishery sites in the Deben estuary is shown in Table 3.1 and Figure 3.1.

Table 3.1 Qualitative assessment of changes in pollution load.

Pollution source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sewage treatment works							+	+				
Intermittent discharges												
Agricultural sources												
Boats							+	+				
Waterbirds												

+ Peak tourism season
Red - high risk; orange - moderate risk.

The bulk of contaminating sources are located towards the head of the estuary at Woodbridge. These include the main continuous sewage discharges, the majority of intermittent discharges, and the majority of freshwater inputs which will carry contamination associated with agricultural and urban runoff. Therefore an overall gradient of increasing contamination from the mouth of the estuary to Woodbridge is anticipated. Overlaid on this there are some potential local influences, notably Shottisham Creek, which may cause a small hotspot of contamination at its mouth just south of the Girlings Hard site, and Kirton and Falkenham Creeks which discharge to the west bank down estuary from Spinny Marsh. Overboard discharges from boats are likely to be of significance as there are large numbers of yachts using the estuary, mainly during the summer months. Moorings are widely distributed throughout the estuary, but there is a concentration of these in the vicinity of the fishery just off Waldringfield. There is a significant presence of waterbirds within the estuary, with numbers peaking during the winter, but inputs from these are spatially diffuse, and so will not influence the location of the RMPs.

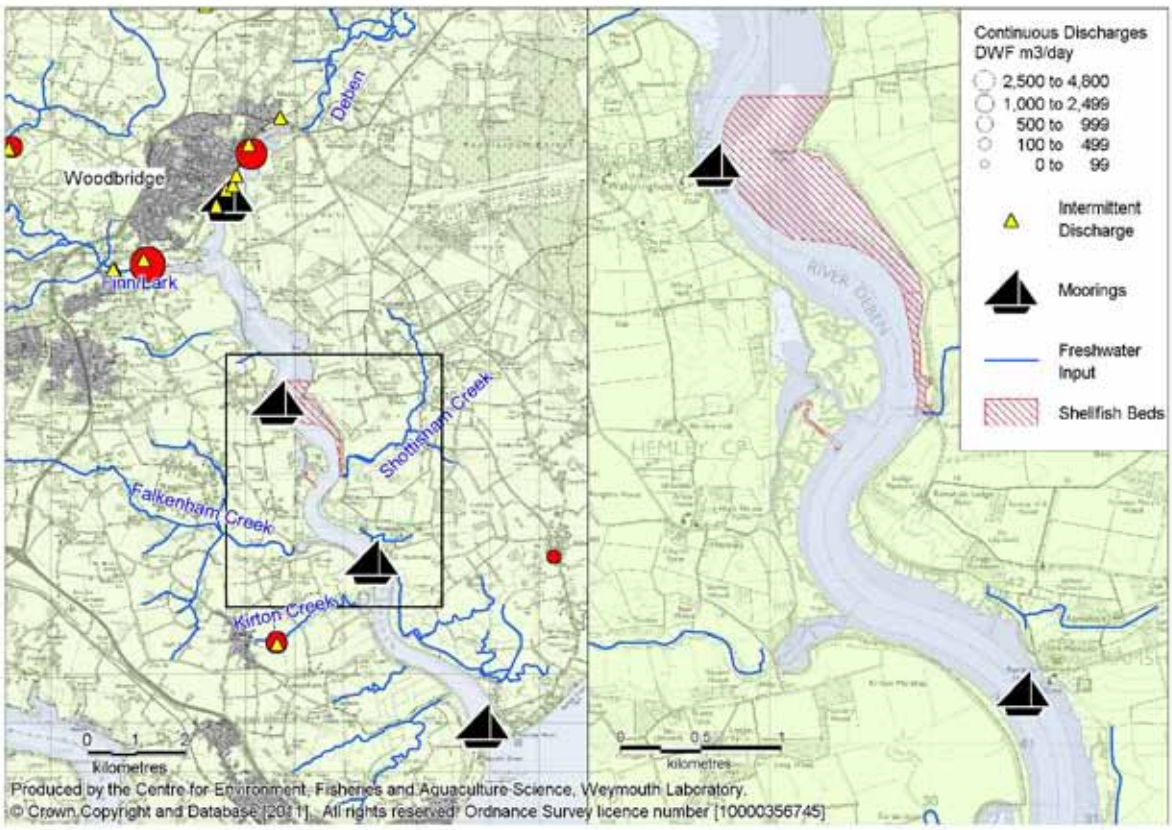

Figure 3.1 Significant sources of microbiological pollution to the Deben estuary.

HYDRODYNAMICS

The Deben estuary consists of a single meandering channel about 18km in length flanked by intertidal areas of mudflats and saltmarsh. The navigable channel becomes shallower, narrower and more meandering at Waldringfield, and the size of the intertidal area also increases. The fishery sites lie within the middle reaches of the estuary. Spinny Creek is a shallow subtidal side channel flanked by an intertidal area of soft mud. Girlings Hard is a relatively gently sloping intertidal area flanking the main channel with a mixed substrate of sand, gravel and mud.

Tidal flows dominate water circulation patterns within the estuary, flowing northward on a flood tide, and southwards on an ebb tide. Girlings Hard and the area to the north will be therefore be impacted by any sources both up and down estuary, whereas Spinny Creek will fill with water during the flood, and drain on the ebb, so any sources discharging to the west bank to the south of the fishery, such as Kirton Creek may be of increased significance.

The tidal excursion within the estuary is in the very approximate order of 5-10km, depending on tidal amplitude. As the fishery lies between about 5 and 8 km downstream of the Woodbridge area, contamination released at Woodbridge would be expected to arrive at the fishery site towards the end of the ebb tide. Greater impacts from sources at Woodbridge may be anticipated at the northern boundaries of the fishery, and more extensive impacts would be expected during spring tides. Shellfish beds even a relatively short distance

further up the estuary may be subject to greater and more regular impacts from sources at the head of the estuary. Also, shellfish lower down the foreshore would be exposed to the more contaminated water which is likely to be present around low water. Therefore RMPs set towards the low water mark at the northern boundary of the fishery on the east bank are likely to capture peak levels of contamination given the absence of significant local sources. The influence of sources at Woodbridge is likely to be lowest at Spinny Creek. This site will be subject to contamination from a different profile of sources, so should be monitored separately from sites on the east shore. As there are no sources discharging direct to Spinny Creek, no consistent or significant spatial variation in levels of contamination are expected within it.

Freshwater inputs to the estuary are very low relative to tidal exchange, so density effects are thought unlikely to significantly modify water circulation patterns for the vast majority of the time. A gradient of decreasing salinity towards the head of the estuary has been observed. As much of the contamination entering the estuary is likely to be carried by these freshwater inputs, this provides tentative support to the conclusion that there is a general gradient of increasing contamination towards the head of the estuary. Although wind effects may modify circulation patterns within the estuary at times, these effects will not be consistent or predictable, so will not be taken into consideration for the sampling plan.

SUMMARY OF EXISTING MICROBIOLOGICAL DATA

No relevant microbiological data was available, aside from the samples taken during the shoreline and bacteriological surveys. The shoreline survey samples arrived at the lab 3 days after they were collected, which is outside of the advised limit of 24 hours. The results must be therefore be treated with caution and cannot be used for classification purposes. Both shellfish and water sample results indicated higher levels of contamination in the upper reaches of the estuary north of Waldringfield compared to those taken in the vicinity of Spinny Marsh and Girlings Hard. A seawater sample taken at the mouth of Shottisham Creek contained relatively low levels of *E. coli*, suggesting that this watercourse did not create a hotspot of contamination at the south end of Girlings Hard at the time of sampling. Paired samples of mussels and oysters were taken at points at the north and south ends of Girlings Hard, with both species yielding similar results.

For the bacteriological survey, 10 sets of Pacific oyster samples were taken from three points, one within Spinny Creek, and the other two at the north and south ends of Girlings Hard. They were taken between February and May 2011. On average, levels of contamination were highest at Spinny Marsh, and lowest at Girlings Hard South. Results were significantly higher at Spinny Creek compared to Girlings Hard South. At Girlings Hard South no results exceeded 230 *E. coli* MPN/100g. It must be noted that these results only cover a limited period of the year, and significant seasonal fluctuations in *E. coli* levels may arise here. The spatial patterns in *E. coli* levels observed in oysters are likely to be similar for other species.

4. RECOMMENDATIONS

4.1 As the main fishery sites at Spinny Creek and Girlings Hard are likely to be subject to contamination from differing sources, and a significant difference in results from these two areas was observed during the bacteriological survey, separate classification zones should be defined for these.

4.2 No consistent spatial variation in levels of contamination within Spinny Creek is anticipated, so the RMP used for the bacteriological survey at TM 2923 4301 can be retained for ongoing monitoring purposes.

4.3 Within the classification zone at Girlings Hard, potential contaminating influences are Shottisham Creek, to the south, and the main sources at Woodbridge, some distance to the north. Sampling results suggest that Shottisham Creek is not a significant contaminating influence, so the RMP for this zone should be set at the north end of the site, as low down the intertidal zone as it practical (TM 2983 4380). This represents a slight (~25m) relocation in a north westerly direction from the Girlings Hard North RMP used in the bacteriological survey.

4.4 In order to classify the wider intertidal area of the east bank to beyond Stonner Point, an RMP should be set at the northern edge of this zone (TM 2910 4500) to capture contamination from the Woodbridge area. After one year's parallel monitoring at the Stonner Point and Girlings Hard RMPs, if results are very similar between the two, the two zones could be amalgamated and monitored as one at whichever RMP yielded the highest overall result. Should further expansion northwards up the east bank be required at a later date, a similar approach should be adopted (in consultation with Cefas/FSA).

4.5 Should the classification require extension to the south of Shottisham Creek, an RMP should be established at the mouth of this watercourse. After one of year parallel monitoring with the Girlings Hard RMP (or Stonner Point) if results are very similar between the two (or three) the zones could be amalgamated and monitored as one at whichever RMP yielded the highest overall result.

4.6 Recommendations 4.3, 4.4 and 4.5 should be applied to the mussel fishery on the east bank.

4.7 Recommendation 4.2 should be applied for cockles at Girlings Hard.

4.8 Should a native oyster fishery be developed within Spinny Creek, recommendation 4.2 should be applied. Should a native oyster fishery be developed at Girlings Hard, recommendation 4.3 should be applied.

4.9 A 10m tolerance should be applied to all these RMPs. Bagged shellfish may be used to ensure repeated sampling is possible from each of

these RMPs. Stock should be of a harvestable size, and should be in place at least two weeks before it is sampled.

4.9 Should parallel monitoring of different species at the same RMP yield very similar results after one year's results, consideration should be given to monitoring only the species yielding the highest peak result, subject to monitoring results and further development of FSA policy in this area.

5. SAMPLING PLAN

GENERAL INFORMATION

Location Reference

Production Area	Deben
Cefas Main Site Reference	M010
Cefas Area Reference	FDR 7318
Ordnance survey 1:25,000 map	OS Explorer 197 (Ipswich, Felixstowe and Harwich)
Imray Chart	Imray 2000.3 (River Deben and Orford Haven)

Shellfishery

Species/culture	Pacific oysters (*Crassostrea gigas*)	Wild & cultured
	Mussels (*Mytilus* spp.)	Wild
	Cockles (*Cerastoderma edule*)	Wild
	Native oysters (*Ostrea edulis*)	Cultured
Seasonality of harvest	Year round	

Local Enforcement Authority

Name	Suffolk Coastal District Council Council Offices Melton Hill Woodbridge Suffolk IP12 1AU
Environmental Health Officer	V Johnston
Telephone number (	01394 444629
Fax number	01394
E-mail Š	v.johnston@suffolkcoastal.gov.uk

REQUIREMENT FOR REVIEW

The need for this sampling plan to be reviewed will be assessed by the competent authority within six years or in light of any obvious known changes in sources of pollution of human (e.g. improvements in sewage treatment works) or animal origin likely to be a source of contamination for the bivalve mollusc production area.

Table 5.1 Number and location of representative monitoring points (RMPs) and frequency of sampling for classification zones in within the Deben estuary.

Classification zone	RMP	RMP name	NGR	Latitude & Longitude (WGS84)	Species	Growing method	Harvesting technique	Sampling method	Tolerance	Frequency	Comments
Spinny Creek	B010G/ B010I	Spinny Marsh	TM 2923 4301	52°2.28'N 1°20.45'E	*C. gigas, O. edulis*	Bags under floats	Hand	Hand	10m	Monthly	Only sample native oysters if /when classification is required for this species.
Girlings Hard	B010K/ B010L/ B010M/ TBA if required	Girlings Hard	TM 2983 4380	52°2.70'N 1°21.01'E	*C. gigas, Mytilus* spp., *O. edulis, C. edule*	Wild/ cultured	Hand	Hand	10m	Monthly	Only sample native oysters, mussels and cockles if /when classification is required for this species.
Rockhall to Stonner Point	B010N/ B010O	Stonner Point	TM 2910 4500	52°3.36'N 1°20.42'E	*C. gigas, Mytilus* spp.	Wild	Hand	Hand	10m	Monthly	Only sample mussels if a classification is required for this species within this zone. 10 samples will be required before a classification can be issued. Should parallel monitoring alongside Girlings Hard give very similar results, the two zones may be amalgamated and monitored together using whichever RMP gives the highest individual result.
Shottisham Creek	B010J/ B010P	Shottisham Creek	TM 2999 4305	52°2.29'N 1°21.12'E	*C. gigas, Mytilus* spp.	Wild or cultured	Hand	Hand	10m	Monthly	Only to be sampled if and when the harvester requires an extension here for the purposes of preharvest holding of stock. Should parallel monitoring alongside Girlings Hard give very similar results, the two zones may be amalgamated and monitored together using whichever RMP gives the highest individual result.

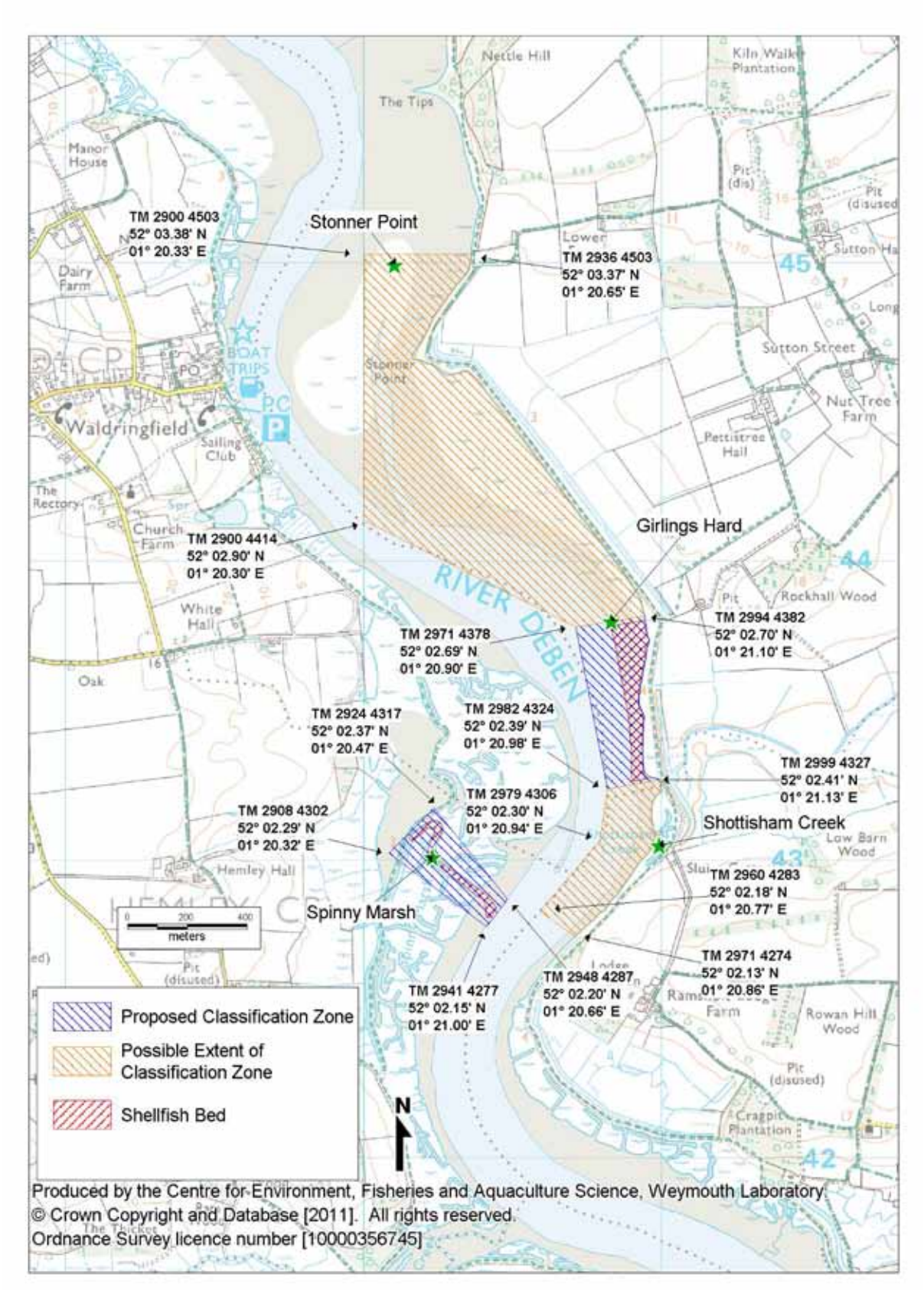

Figure 5.1 Recommended classification zone boundaries and RMP locations.

APPENDICES

APPENDIX I
HUMAN POPULATION

Figure I.1 shows population densities in census output areas within or partially within the Deben estuary catchment, as recorded at the last census (2001).

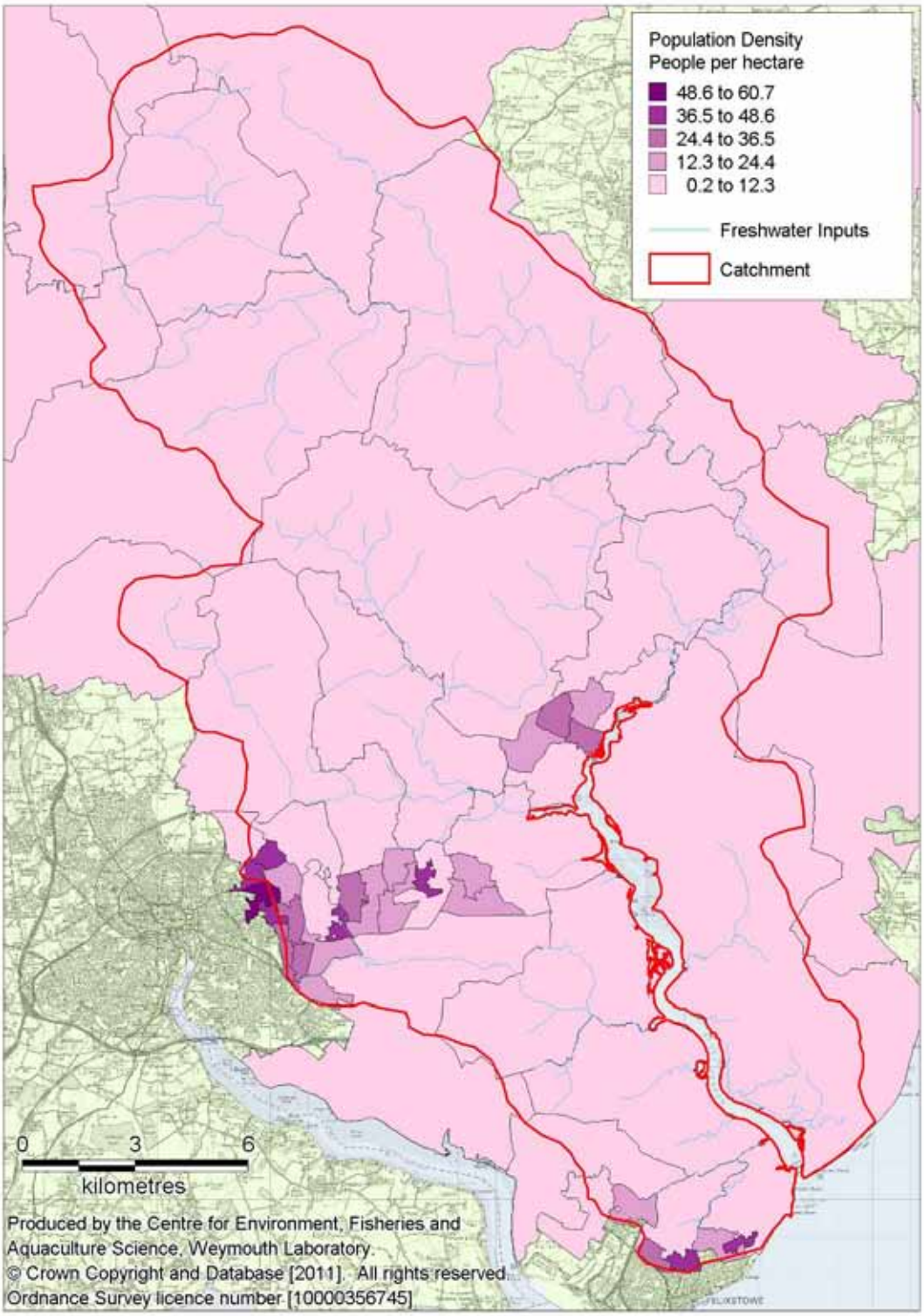

Figure I.1 Human population density in Census Areas within the Deben estuary catchment.

The overall population density within the census output areas shown in Figure I.1 is 138 people/km^2. Population densities are highest within the eastern outskirts of Ipswich, at Woodbridge and at Felixstowe Ferry, and that the rest of the catchment is sparsely populated. Therefore, greatest inputs of human sewage may be expected at the head of the estuary, although this will be dependent on the configuration of the sewerage networks.

The area has several visitor attractions, such as Sutton Hoo and several golf courses, as well as appealing countryside and waterfronts. The estuary itself is a popular destination for visiting yachts. An internet search revealed at least 10 establishments offering tourist accommodation within Woodbridge and its surroundings, and tourism is a significant industry within the area. Therefore it can be concluded that there will be seasonal variation in population levels in the catchment of the Deben estuary, and that population will be highest in summer and lowest in winter, and the bacterial loadings generated by sewage treatment works serving the area will fluctuate accordingly.

APPENDIX II
HYDROMETRIC DATA: RAINFALL

The pattern of rainfall variation in England and Wales tends to be associated with Atlantic depressions or with convection, atmospheric humidity and altitude (Met Office, 2011). Suffolk is one of the driest counties in England, with an average annual rainfall of only 533mm at Woodbridge from 2003 to 2009. This compares with an average annual rainfall for England and Wales of approximately 1,250 mm (Perry, 2006).

Historical data from the network of stations maintained by the Met Office shows a much more even distribution of rainfall throughout the year in Eastern England than in most other parts of the UK. This is due to the combined effect of the rain-shadow for winter Atlantic depressions produced by higher grounds to the west and higher frequency of convective rainfall in summer (Met Office, 2011).

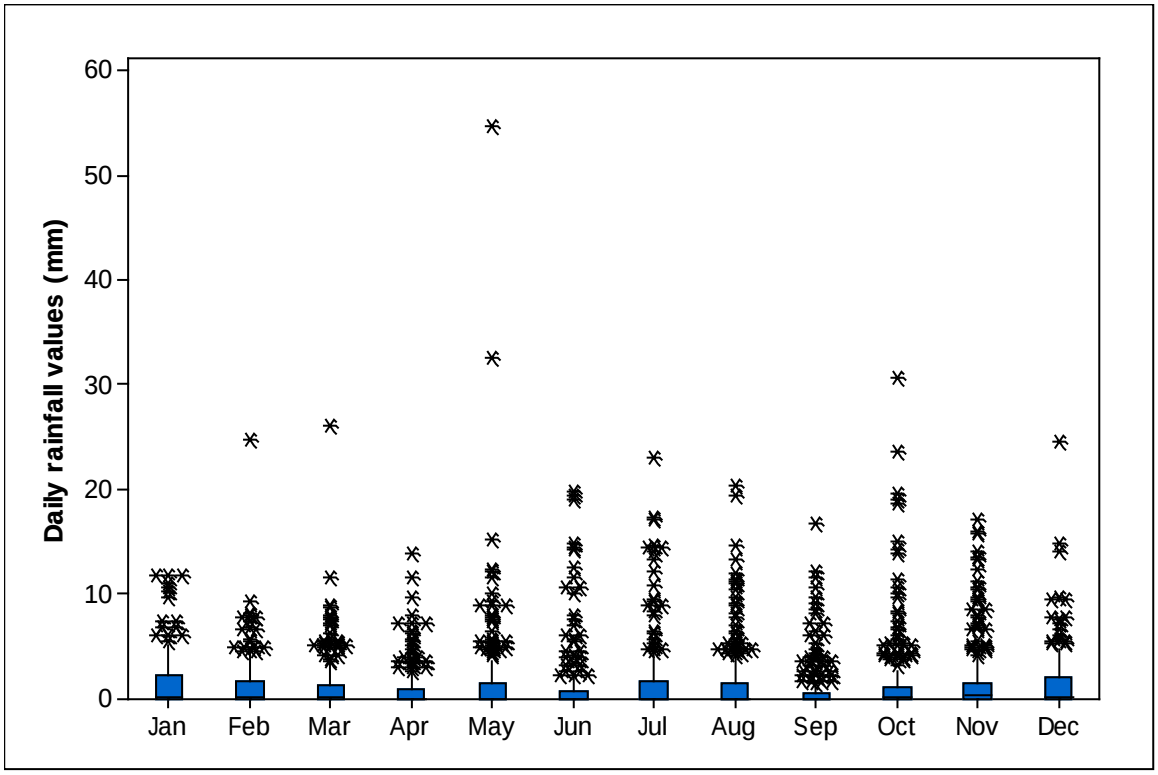

Figure II.1. Box and whisker plot of total daily rainfall values (Jan 2003 to December 2009) by month at Woodbridge.
Data from the Environment Agency (2011).

Rainfall at Woodbridge did not show a particularly marked seasonal variation in average rainfall values by month, and rainfall totals for each month varied considerably between years. Therefore it is concluded that there is no strong seasonal pattern of rainfall at Woodbridge. High rainfall events (over 20mm in a day) were rare, but recorded in most months, so, taken together with the unpredictable seasonal variations it is concluded that sewer overflows may happen at any time of the year. High rainfall events following a period of dry weather may generate a 'first flush' of more contaminated runoff from pastures.

APPENDIX III
HYDROMETRIC DATA: FRESHWATER INPUTS

Figure III.1 shows the most significant freshwater inputs to the Deben estuary, and the location of the flow gauging station on the Deben at Naunton.

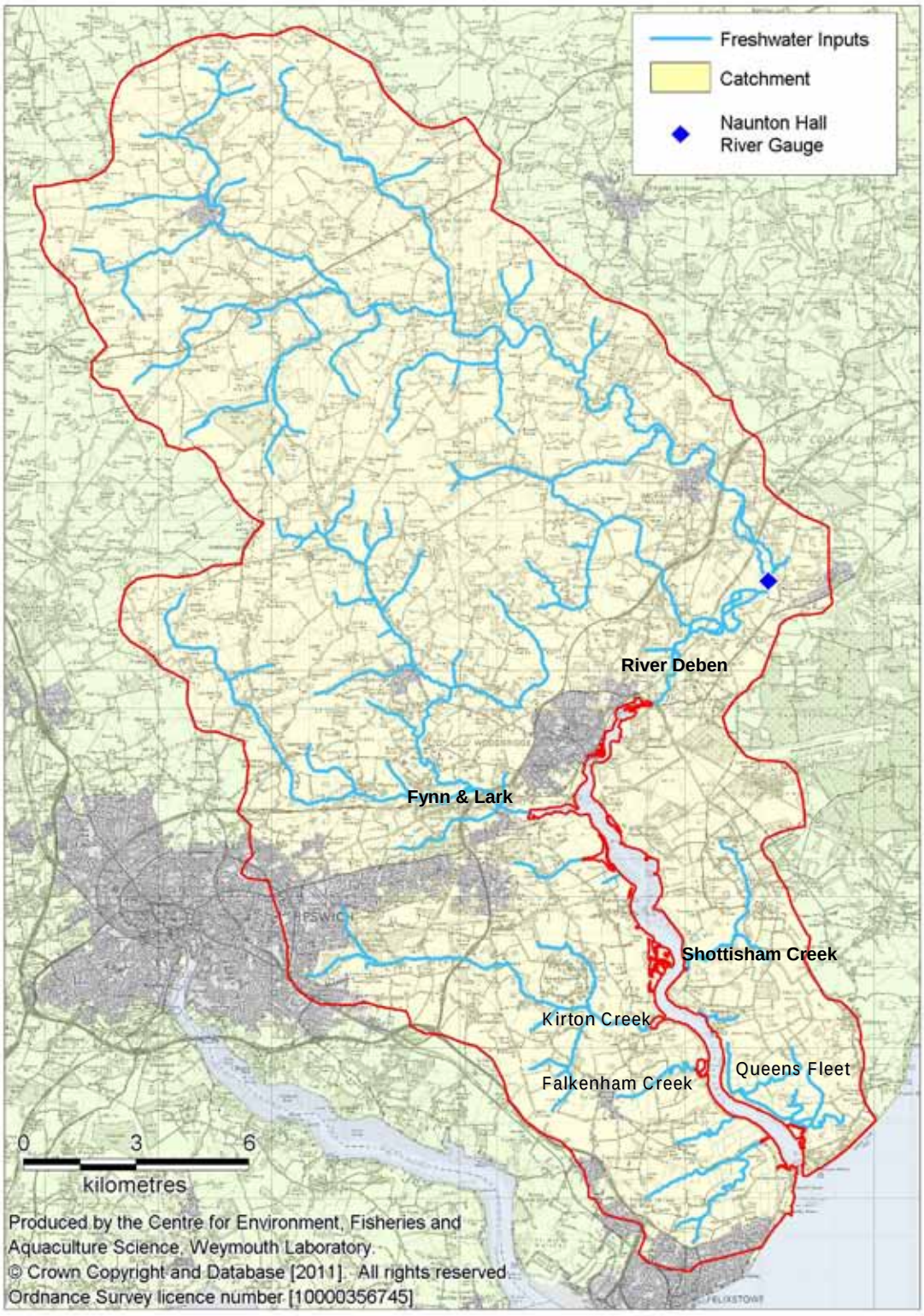

Figure III.1 Freshwater inputs to the Deben estuary and location of river flow gauging station

The main freshwater input is the River Deben, and there are also a number of smaller watercourses discharging to the estuary, including the Fynn & Lark, which also discharge towards the head of the estuary. The majority of the area drained by these watercourses is arable farmland, to which manures may be applied at certain times of the year. There are also some pockets of pasture and built up areas which may potentially generate more highly contaminated runoff. Of local significance to the fishery are Shottisham Creek, which discharges to the east shore immediately south of Girlings Hard, and a small surface water outfall from an area of reclaimed farmland about 200m to the north of Girlings Hard. In addition, Kirton Creek discharges to the west shore about 1km south of Spinny Creek. There are no freshwater inputs at the head of Spinny Creek.

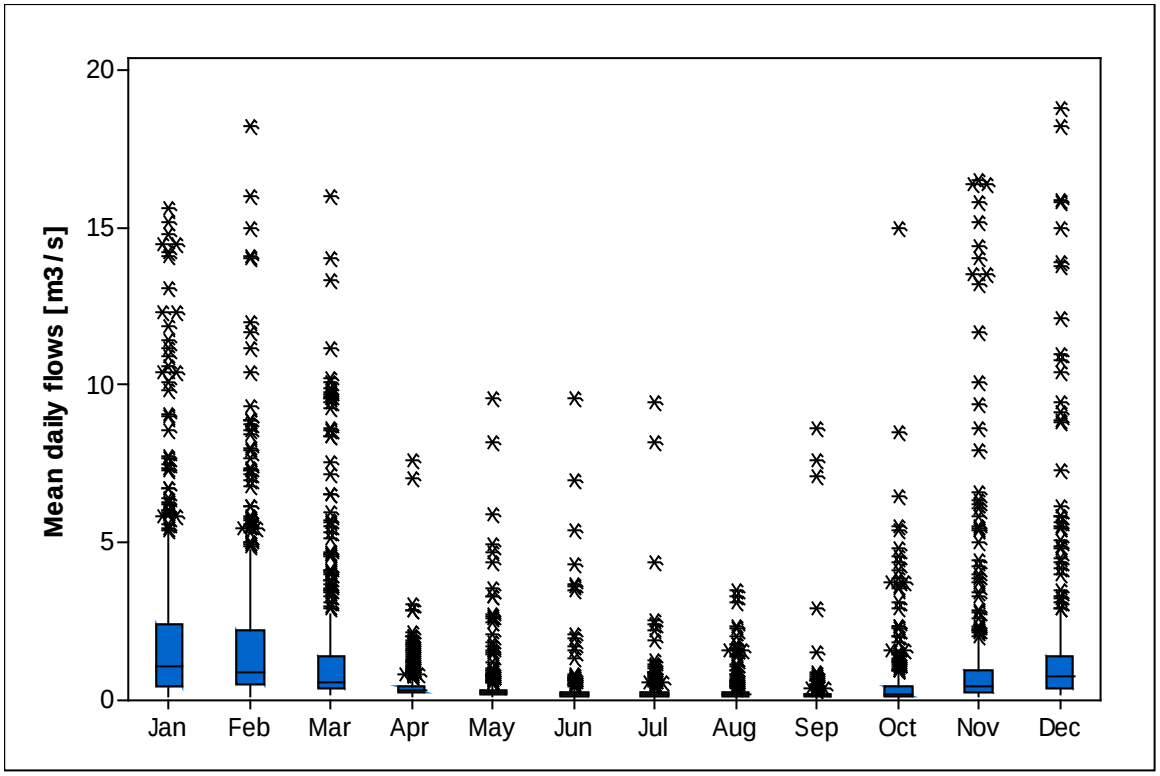

Figure III.2. Box and whisker plot of flows recorded on the River Deben at Naunton, January 2001 to January 2011.
Data from the Environment Agency (2011).

The gauging station at Naunton is located about 2km upstream of the tidal limit of the Deben, and has a catchment area of 163km^2, so carries the runoff from about 40% or the land within the Deben estuary catchment area. From 1964 to 2009, the mean discharge was 0.768m^3/sec, and flows exceeded 1.62m^3/sec for 10% of the time (NERC, 2011b). Therefore, the mean freshwater discharge to the entire estuary is unlikely to exceed 2 m^3/sec. Figure III.2 indicates that despite the lack of seasonal variation in rainfall, a strong seasonal pattern in river discharge is apparent. Average and peak flows are considerably higher from November to March, and this is presumably due to decreased evaporation and transpiration and more waterlogging of soils during the colder weather. A

similar seasonal pattern is likely to be observed in other watercourses draining to the estuary.

Kay *et al*. (2008a) investigated catchment export coefficients for faecal indicator bacteria (cfu km^{-2} hr^{-1}) in a range of river catchments in the UK under a range of conditions, and found that these increased by roughly 2 orders of magnitude from base to high flow conditions in both summer and winter. Whilst catchment export coefficients were not significantly different at base flow conditions between summer and winter, at high flow conditions they were significantly higher in summer than in winter. This seasonal difference was attributed to lower faecal input to pasture land and more frequent flushing during the winter. Therefore, although high flow events do not occur here in summer to the same extent as in winter, elevated river levels in the summer may be associated with peak fluxes of faecal contamination into the estuary from land runoff.

APPENDIX IV
HYDROGRAPHIC DATA: BATHYMETRY

The Deben estuary is a drowned river valley, and consists of a single meandering channel about 18km in length from its mouth to its tidal limit. The mouth is a narrow channel about 180m wide flanked by sea defences, and is the main constriction within the estuary. As a consequence tidal flows are likely to be most rapid with the highest potential for turbulent mixing here. Just inside the entrance there is an intertidal sandbank which, together with the narrow entrance, provides protection against incoming swells. The estuary widens to a relatively uniform navigable channel varying between 3-7m in depth relative to chart datum and 200m in width which is flanked by intertidal areas of mudflats and saltmarsh about 200m wide on either side throughout its outer reaches. The navigable channel becomes shallower, narrower and more meandering at Waldringfield, and the size of the intertidal area also increases. At Woodbridge, almost the entire estuary is intertidal. Therefore, there may be less potential for dilution within the upper reaches of the estuary, particularly at low water, but a higher proportion of the waters here will be exchanged each tide.

Spinny Creek consists of a shallow subtidal side channel flanked by an intertidal area of soft mud. Girlings Hard is a relatively gently sloping intertidal area flanking the main channel with a mixed substrate of sand, gravel and mud. Figure IV.1 shows the bathymetry of the Deben estuary.

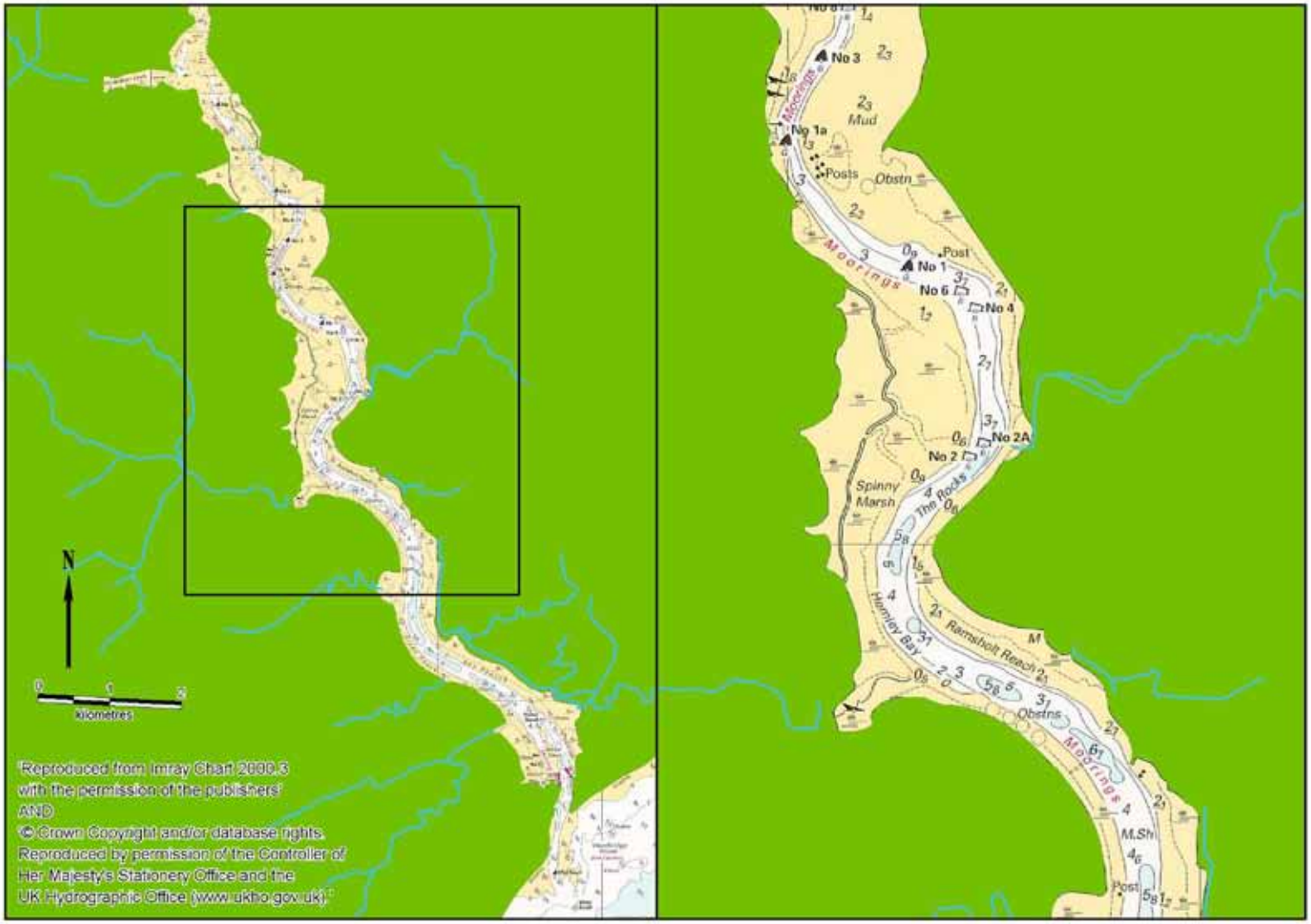

Figure IV.1. Bathymetry of the Deben estuary

APPENDIX V
HYDRODYNAMIC DATA: WATER CIRCULATION PATTERNS

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.

TIDALLY DRIVEN CIRCULATION

Mean high and low water levels and the spring and neap tidal range are shown for the Woodbridge, at the head of the estuary, and Woodbridge Haven, at its mouth in Table V.1.

Table V.1 Tide levels and ranges in the Deben estuary.

	Height (m) above Chart Datum				Range (m)	
Port	MHWS	MHWN	MLWN	MLWS	Spring	Neap
Woodbridge	4.00	3.10	0.90	0.40	3.60	2.20
Woodbridge Haven	3.70	2.90	1.00	0.50	3.20	1.90

Predictions based on Walton-on-the-Naze.
Data from Proudman Oceanographic Laboratory (2011).

The estuary can be described as meso-tidal, with a mean tidal range at Woodbridge of 2.2m and 3.6m on neap and spring tides respectively. Tides arrive at Woodbridge about 40 minutes after they arrive at the mouth, and there is a mild amplification of tidal range towards the head of the estuary. 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 the estuary on the ebb, although it is possible that eddies may form in some places. 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 impact will decrease with increasing distance as the plume spreads. At Girlings Hard, shoreline sources to the east shore in close proximity or directly to the fishery will impact most heavily. Spinny Creek will fill during the flooding tide, and drain during the ebb tide, so contamination from sources to the west shore just south of this creek will be carried in on the flooding tide and impact most heavily here.

Peak spring flood velocities are reported as 0.5m/s, and peak ebb velocities are 0.75m/s, with neap tidal velocities 0.1 to 0.2m/s slower (ABP Marine Environmental Research, 2008). This would suggest that tidal excursions are in the very approximate order of 5-10km, tentatively implying that contamination entering the estuary in the Woodbridge area (about 7-9km upstream of the fishery) may only be carried as far as the Girlings Hard and Spinny Creek on an ebbing tide during spring tides, but would impact more heavily and regularly a few km upstream. Shellfish lower down the intertidal zone, towards the low water mark will be more exposed to contamination arriving towards the end of the ebb tide.

FRESHWATER INPUTS

The mean freshwater input to the estuary is low (estimated at around 2 m^3/sec) in relation to tidal exchange (peak spring flows at the mouth of around 2000 m^3/sec), so flows within the estuary are tidally dominated. The estuary is reported to be well mixed (ABP Marine Environmental Research, 2008). Two vertical salinity profiles taken during the shoreline survey indicated little difference in salinity within the water column. Density effects are therefore anticipated to be of negligible impact on water circulation patterns within the Deben estuary for the vast majority of the time.

Most freshwater enters towards the head of the estuary from the Deben & Fynn/Lark catchments. Surface salinity measurements taken during the shoreline survey showed a steady decrease in salinity from about 27ppt in the vicinity of the fishery to about 20ppt by the entrance of Martlesham Creek. Flow gauging records from the Deben at Naunton indicate that river discharge was relatively low at the time of survey, with mean daily flows of 0.413 and 0.534 m^3/sec on the 29th and 30th November 2010. Therefore, a horizontal gradient in salinity throughout the estuary is anticipated, and during high flow events very low salinities may arise towards the head of the estuary. A water quality model for the estuary was developed to assist the Environment Agency in setting discharge consents (Environment Agency, 1997). The model, and supporting observations indicate that salinity rapidly increases from the head of tide through to about 30ppt at Woodbridge, then continues to gradually increase to about 32ppt at Shottisham Creek. Fluctuations in salinity within the high/low tidal cycle are very marked at the head of the estuary, but are relatively minor (about 2ppt) in the vicinity of the fishery. As contamination from land runoff and most of the sewage discharges is carried into the estuary by these freshwater inputs, it is likely that levels of *E. coli* within the estuary will generally increase as salinity decreases towards the head of the estuary.

WIND EFFECTS

The prevailing winds in East Anglia are from the southwest quadrant, and the frequency of gales is relatively low. Strong winds may modify patterns of water circulation within the Deben estuary. Winds typically drive surface water currents at about 3% of the wind speed (Brown, 1991) so a gale force wind (17.2m s^{-1}) would drive a surface water current of about 1 knot or 0.5m s^{-1}. Therefore, gale force winds could potentially drive surface currents at a similar velocity to tidal currents, although the two will be superimposed on each other. Wind driven surface currents will create return currents flowing in the opposite direction either lower in the water column or along sheltered margins. Winds may also create wave action which may re-suspend contamination from within intertidal sediments.

SUMMARY AND CONCLUSIONS

It is anticipated that tidal flows dominate water circulation patterns within the estuary. These will flow northwards on a flood tide, and southwards on an ebb tide. Girlings Hard will be therefore be impacted by sources both up and down

estuary. Sources discharging to the east shore in close proximity to the site are most likely to cause localised spatial differences in levels of contamination across the site. The site at Spinny Creek will fill with water during the flood, and drain on the ebb. Therefore sources discharging to the west bank, to the south of the fishery will be of particular significance as contamination from these will be carried into Spinny Creek as the tide floods.

The tidal excursion within the estuary is in the very approximate order of 5-10km, tentatively implying that contamination entering the estuary in the Woodbridge area, which lies about 5-6km upstream of the northern boundary of the wider area requiring classification and about 7-9km upstream of the main fishery areas at Girlings Hard and Spinny Creek, may only be carried as far as the fishery on an ebbing tide during spring tides. Shellfish beds even a relatively short distance further up the estuary may be subject to greater and more regular impacts from sources at the head of the estuary, and those lower down the foreshore would still be immersed towards low water when contamination from up estuary would be most prevalent. Freshwater inputs are unlikely to significantly modify circulation patterns for the vast majority of the time. Most freshwater enters in the vicinity of Woodbridge, and a gradient of decreasing salinity towards the head of the estuary has been observed. As much of the contamination entering the estuary is likely to be carried by these freshwater inputs, this is also likely to translate to a similar overall gradient in levels of *E. coli*, although inputs from other sources will be superimposed on this. Wind effects may modify circulation patterns within the estuary, but their effects will be dynamic, superimposed on tides, and difficult to generalise about.

APPENDIX VI
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, 2011). As Atlantic depressions pass England and Wales, the wind typically comes from the west or northwest as the depression moves away. For this reason East Anglia is one of the less windy parts of England and Wales. A wind rose for Coltishall (approximately 75km north of Woodbridge) shows that the prevailing wind direction is from the south-west and that the strongest winds nearly always blow from the range of directions west-southwest (Figure VI.1). The frequency of gales is relatively low.

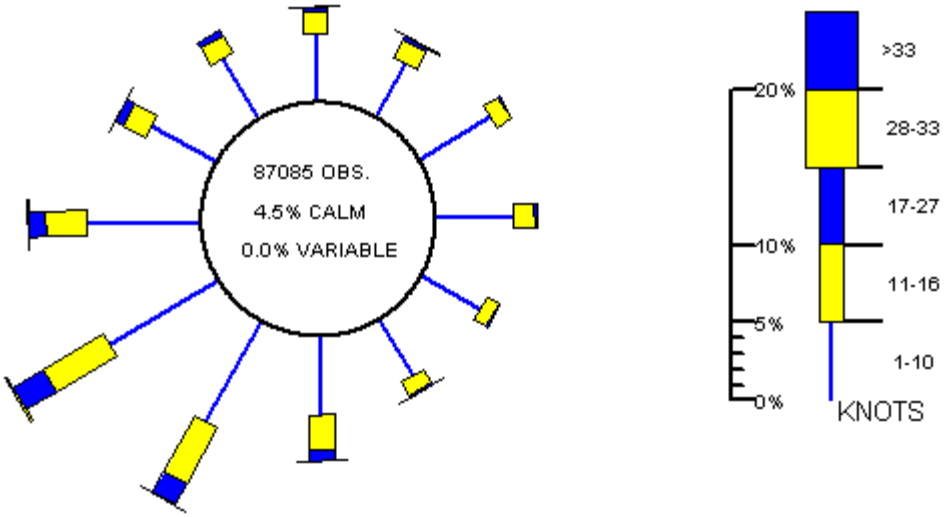

Figure VI.1 Wind rose for Coltishall, Norfolk.
Period of data: January 1995–December 2004.
Modified under permission by the Met Office.

The north-south orientation of the Deben estuary will mean it receives some shelter from the prevailing winds from the surrounding land, although this will be limited as the land is low lying. As winds from the southern quadrant are more frequent than from the northern quadrant, they will tend to blow up the estuary for more of the time. The potential impacts of wind on the circulation of water within the Deben estuary as discussed in Appendix V.

APPENDIX VII
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: SEWAGE DISCHARGES

The Deben estuary catchment area contains 21 water company sewage treatment works of varying sizes, all of which provide secondary treatment. Associated with these works are various intermittent discharges. Details of water company discharges, provided by the Environment Agency from their National Discharge Database in October 2010, are presented in Tables VII.1 and VII.3, and their locations are show in Figure VII.1. In addition to this, a number of properties are served by small private discharges. Their locations are shown in Figure VII.1, but individual details are not presented as all are minor, serving either one or a small number of properties.

Table VII.1 Continuous water company sewage discharges to the Deben estuary catchment (all provide secondary treatment).

Name	DWF (m^3/day)	NGR of outfall	Discharges to (catchment**/location)	Distance from fishery (km)
Alderton STW	82	TM 3430 4140	Watercourse (Queens Fleet trib)	10
Charsfield STW	63	TM 2660 5600	Watercourse (Deben)	17
Debenham STW	444	TM 1807 6356	Watercourse (Deben)	41
Earl Soham STW	80	TM 2330 6280	Watercourse (Deben)	34
Easton(Suffolk) STW	19	TM 2840 5840	Watercourse (Deben)	23
Great Bealings STW	22*	TM 2275 4912	Watercourse (Lark trib)	11
Grundisburgh STW	347	TM 2315 4977	Watercourse (Lark)	12
Helmingham STW	6	TM 1890 5850	Watercourse (Deben)	40
Henley STW	107	TM 1661 5157	Watercourse (Fynn)	20
Kenton STW	1*	TM 1935 6665	Watercourse (Deben trib)	40
Kirton STW	370	TM 2864 3970	Watercourse (Kirton Stream)	6
Little Bealings STW	21*	TM 2259 4787	Watercourse (Fynn trib)	11
Melton STW	1,257	TM 2821 4967	Estuary (at Woodbridge)	7
Monk Soham STW	4	TM 2050 6640	Watercourse (Deben)	39
Otley STW	175	TM 2060 5470	Watercourse (Deben)	19
Pettaugh STW	12*	TM 1662 5980	Watercourse (Deben)	40
Playford STW	16*	TM 2187 4793	Watercourse (Fynn trib)	12
Rendlesham Park STW	645.5	TM 3236 5368 & TM 3230 5363	Watercourse (Deben)	14
Tuddenham STW	420	TM 1954 4765	Watercourse (Fynn)	15
Wickham Market STW	580	TM 3093 5585	Watercourse (Deben)	17
Woodbridge STW	4,800	TM 2598 4728	Estuary (Martlesham Creek)	7

*Consented for a population equivalent rather than DWF. Converted to DWF using an assumed water usage of 200l/head/day.

No bacteriological testing has been carried out on the final effluent from any of these treatment works. As they all provide secondary treatment, their associated bacterial loadings are anticipated to be roughly in proportion to their dry weather flow (DWF). Reference concentrations of faecal coliforms in sewage discharges, subject to differing degrees of treatment, under low and high flow conditions are given in Table VII.2.

Consented dry weather flows to the Fynn/Lark (including Woodbridge STW which discharges to Martlesham Creek) total 5889 m^3/day, those to the River Deben and tributaries (including Melton STW which discharges to the head of the estuary) total 3130.5 m^3/day, and for minor watercourses discharging to the lower estuary consented dry weather flows are 451 m^3/day in total. Therefore,

the vast majority of sewage effluent from water company treatment works enter the estuary in the vicinity of Woodbridge, up estuary from the fishery. Also of potential significance is the Kirton STW, which has a consented DWF of 370 m^3/day and discharges to Kirton Stream on the west bank of the estuary to the south of the fishery, and is located about 6km from the fishery by water, including 3 km via watercourse.

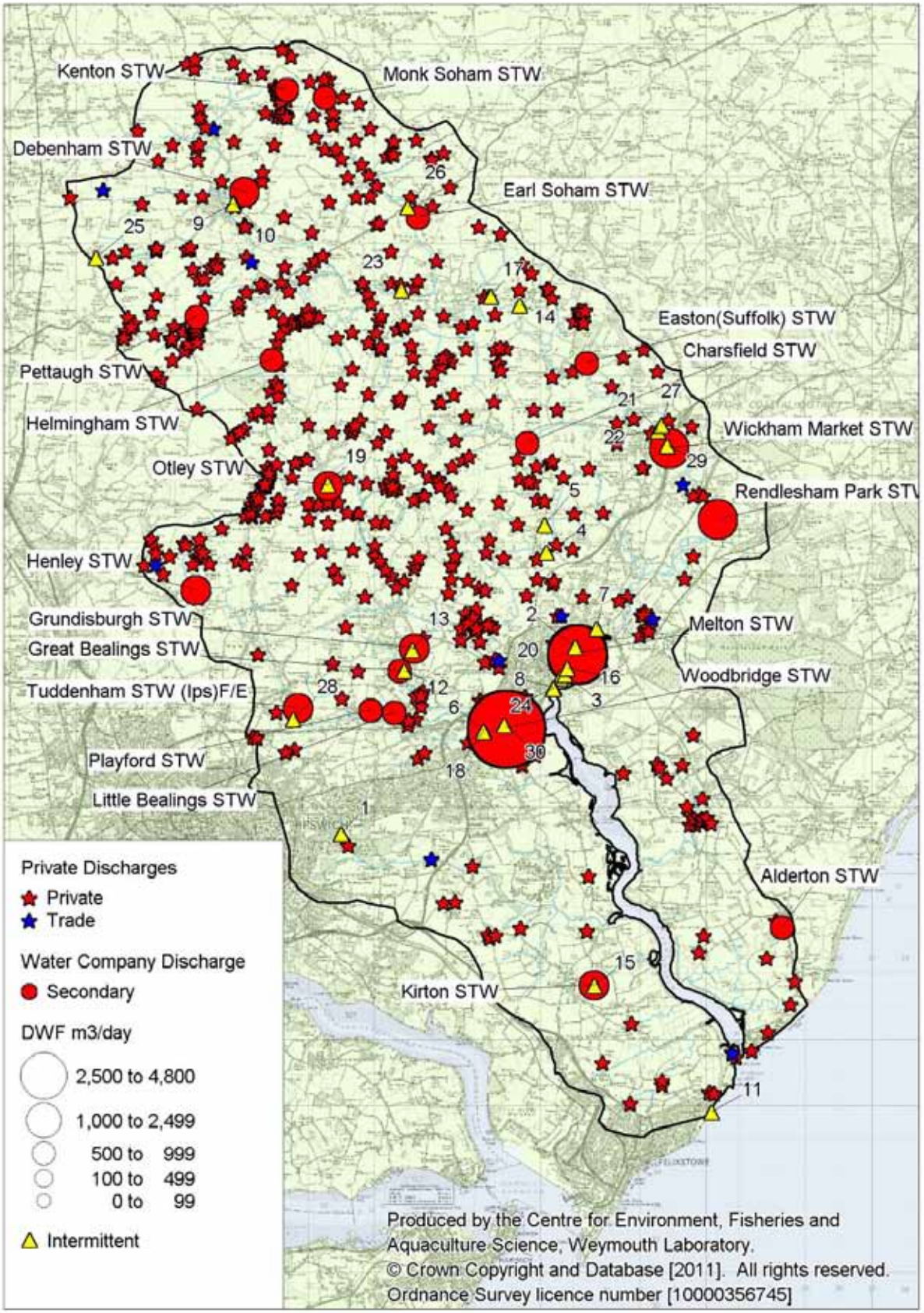

Figure VII.1 Sewage discharges to the Deben estuary catchment

Table VII.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
Primary (12)	127	$1.0x10^7$	14	$4.6x10^6$
Secondary (67)	864	$3.3x10^5$	184	$5.0x10^5$
Tertiary (UV) (8)	108	$2.8x10^2$	6	$3.6x10^2$

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

Intermittent sewage discharges can deliver highly contaminated water to coastal areas resulting from the rapid flushing of stored contaminants during storm conditions and/or the overloading during periods of heavy rainfall (Lee and Morgan, 2003). Contaminant microorganisms in these discharges can be rapidly accumulated by bivalves and deteriorate the microbiological quality of BMPAs (Younger *et al.*, 2003). Intermittent sewage discharges (emergency overflows and combined sewer overflows) directly to the Deben estuary and indirectly via watercourses draining to the bay are listed in Table VII.3.

Table VII.3 Intermittent sewage discharges within the Deben estuary catchment.

No.	Name	Location	Discharges to
1	Bixley Farm PS	TM 2098 4420	Watercourse (Mill River)
2	Blyth Hasel Terminal PS	TM 2805 4984	Estuary (at Woodbridge)
3	Boating Pool (Quay Street) SO	TM 2773 4900	Estuary (at Woodbridge)
4	Bredfield - Dewens Farm PS	TM 2717 5270	Watercourse (Deben)
5	Bredfield - Moat Farm PS	TM 2713 5352	Watercourse (Deben)
6	Bridge SO	TM 2530 4730	Watercourse (Fynn/Lark)
7	Deben Mill SO	TM 2870 5040	Estuary (at Woodbridge)
8	Deben Swimming Pool SO	TM 2740 4860	Estuary (at Woodbridge)
9	Debenham STW SO	TM 1774 6323	Watercourse (Deben)
10	Debenham PS	TM 1773 6320	Watercourse (Deben)
11	Felixstowe - Cliff Rd PS	TM 3216 3582	North Sea (outside estuary)
12	Great Bealings STW SO	TM 2289 4912	Watercourse (Fynn/Lark)
13	Grundisburgh SO	TM 2313 4975	Watercourse (Fynn/Lark)
14	Kettleburgh PS	TM 2638 6014	Watercourse (Deben)
15	Kirton STW SO	TM 2864 3970	Watercourse (Falkenham Creek)
16	Lime Kiln Quay SO	TM 2780 4920	Estuary (at Woodbridge)
17	Low Street SO	TM 2550 6040	Watercourse (Deben)
18	Martlesham SO	TM 2528 4730	Watercourse (Fynn/Lark)
19	Otley STW SO	TM 2059 5474	Watercourse (Fynn/Lark)
20	Quayside SO	TM 2771 4895	Estuary (at Woodbridge)
21	Spring Lane SO	TM 3055 5636	Watercourse (Deben)
22	Spring Lane PS	TM 3055 5636	Watercourse (Deben)
23	Cretingham PS	TM 2280 6060	Watercourse (Deben)
24	Station Road SO	TM 2739 4859	Estuary (at Woodbridge)
25	Stonham Parva PS	TM 1358 6157	Watercourse (Deben)
26	The Bridge SO	TM 2300 6310	Watercourse (Deben)
27	The Bridge PS	TM 3065 5651	Watercourse (Deben)
28	Tuddenham - Donkey Lane SO	TM 1954 4766	Watercourse (Fynn/Lark)
29	Wickam Market STW SO	TM 3088 5596	Watercourse (Deben)
30	Woodbridge STW SO	TM 2598 4729	Watercourse (Fynn/Lark)

PS - pumping station
SO - storm overflow
STW - sewage treatment works.

The majority of these are located at the head of the estuary, or within the River Deben or Fynn/Lark catchments, so greatest impacts from these may be expected towards the head of the estuary. Telemetry records from selected intermittent discharges most likely to be of significance to the fishery were provided by Anglian Water via the Environment Agency. These were the ones discharging direct to the estuary, and the overflows at Kirton and Woodbridge STWs. As the alarm activated when wet well levels were high, rather than when the overflow was operating, the occurrence and volumes of spills from these overflows could not be assessed. Table VII.4 presents the number of incidences when high water level alarms were received.

Table VII.4. Incidences of high water levels alarms received from selected Intermittent outfalls

Name on Table VII.3	Anglian Water name	Start of records	2005	2006	2007	2008	2009	2010
Deben Swimming Pool	Woodbridge-Cinema SP	Sep-05	8	33	39	37	12	11
Boating Pool (Quay Street)*	Woodbridge-Boating Pool SP*	Oct-05	5	8	7	9	12	16
Bridge	Martlesham M Bridge SP	Sep-05	5	14	14	18	12	15
Deben Mill*	Melton-Deben Mill SP*	Aug-07	-	-	149**	10	148**	25
Blyth Hasel Terminal Pumping Station	Melton-Behind Blythe Hasel TPS	Aug-06	-	3	0	3	11	4
Quayside Sewage Pumping Station	Woodbridge-Quayside TPS	Sep-05	6	16	19	15	19	13
Kirton STW	Kirton-Drunkards L STW	Oct-06	-	12	6	0	6	6
Woodbridge STW	Woodbridge STW	Jun-06	-	0	0	0	0	0

*Geographical discrepancy between Environment Agency database and Anglian Water records
**Includes multiple alarms in a short space of time

The only definitive information that can be derived from these records was that the Woodbridge STW storm overflow has not discharged since telemetry was fitted here in June 2006. For all other telemetry records, the high level alarm was triggered on multiple occasions since records began but it is not possible to say what proportion of these alarms was actually associated with a spill from each discharge.

The private discharges shown on Figure VII.1 are small septic tank or package plant treated discharges serving one or a small number of properties, some of which will discharge to a watercourse, others to soakaway. Again, the vast majority lie within the River Deben and Fynn/Lark catchments, although there are 18 of these within the Shottisham Mill catchment area, and 10 within the Kirton Creek catchment area indicating that these watercourse may receive some minor sewage inputs.

In conclusion, the majority of sewage inputs are to the head of the estuary around Woodbridge, or watercourses which discharge to this area. Kirton STW may be of some impact to the Spinny Creek site, and a small number of private discharges to Shottisham Creek and Kirton Creek are likely to contribute to levels of *E. coli* within these watercourses. At times of high rainfall, it is

possible that some of the overflow discharges operate, and again these are mainly found around Woodbridge, or to watercourses which discharge to this area.

APPENDIX VIII
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: AGRICULTURE

Diffuse contamination from livestock will be carried into the estuary via watercourses draining areas of pasture. The extent of this will depend not only on the numbers and distribution and type of livestock, but also rainfall patterns, soil permeability, slope, and the degree of separation between livestock and watercourses. To capture contamination of livestock origin RMPs should be set in a position which most exposes them to plumes originating from these watercourses. The concentration of faecal coliforms excreted in the faeces of animal and human and corresponding loads per day are summarised in Table VIII.1.

Table VIII.1 Levels of faecal coliforms and corresponding loads excreted in the faeces of warm-blooded animals.

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

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

Table VIII.2 shows the numbers of farmed animals by species and sub-catchment area (Figure VII.1) from the June 2009 agricultural survey undertaken by Defra. It must be noted that each farm is allocated to a single point, whereas in practice an individual farm may span two or more catchments. Nevertheless, the information in Table VIII.2 will give a broad overview of livestock farming in the area.

Table VIII.2 Total numbers and densities of livestock by catchment

	Total number				Density (animals/km^2)			
Catchment	Cattle	Pigs	Sheep	Poultry	Cattle	Pigs	Sheep	Poultry
Deben (C035006)	2,156	**	2,518	147,535	12	**	14	822
Deben (Tidal) (C035011)	458	11,256	977	8,213	4	89	8	65
Finn and Lark (C035007)	826	24,412	730	263,884	10	299	9	3,234
Total	3,440	35,668	4,225	419,632	9	92	11	1082

** Data withheld for confidentiality reasons as it relates to less than 5 holdings

Large numbers of pigs and poultry are farmed within the catchment area, and these are generally reared indoors. Process descriptions for three large scale intensive pig operations formed part of the consents for these operations issued by the Environment Agency under the Pollution Prevention and Control Regulations, and in all cases these indicated that manure and dirty water was collected, stored in such a way as to prevent its escape to watercourses or groundwater, and then strategically applied to local arable land. Therefore, widespread periodic applications of manures to the arable farmland which dominates the catchment is anticipated, although the temporal and spatial profiles of these applications is uncertain. It is also possible that sewage sludges are spread on arable land, but no records of such applications are held by the Environment Agency.

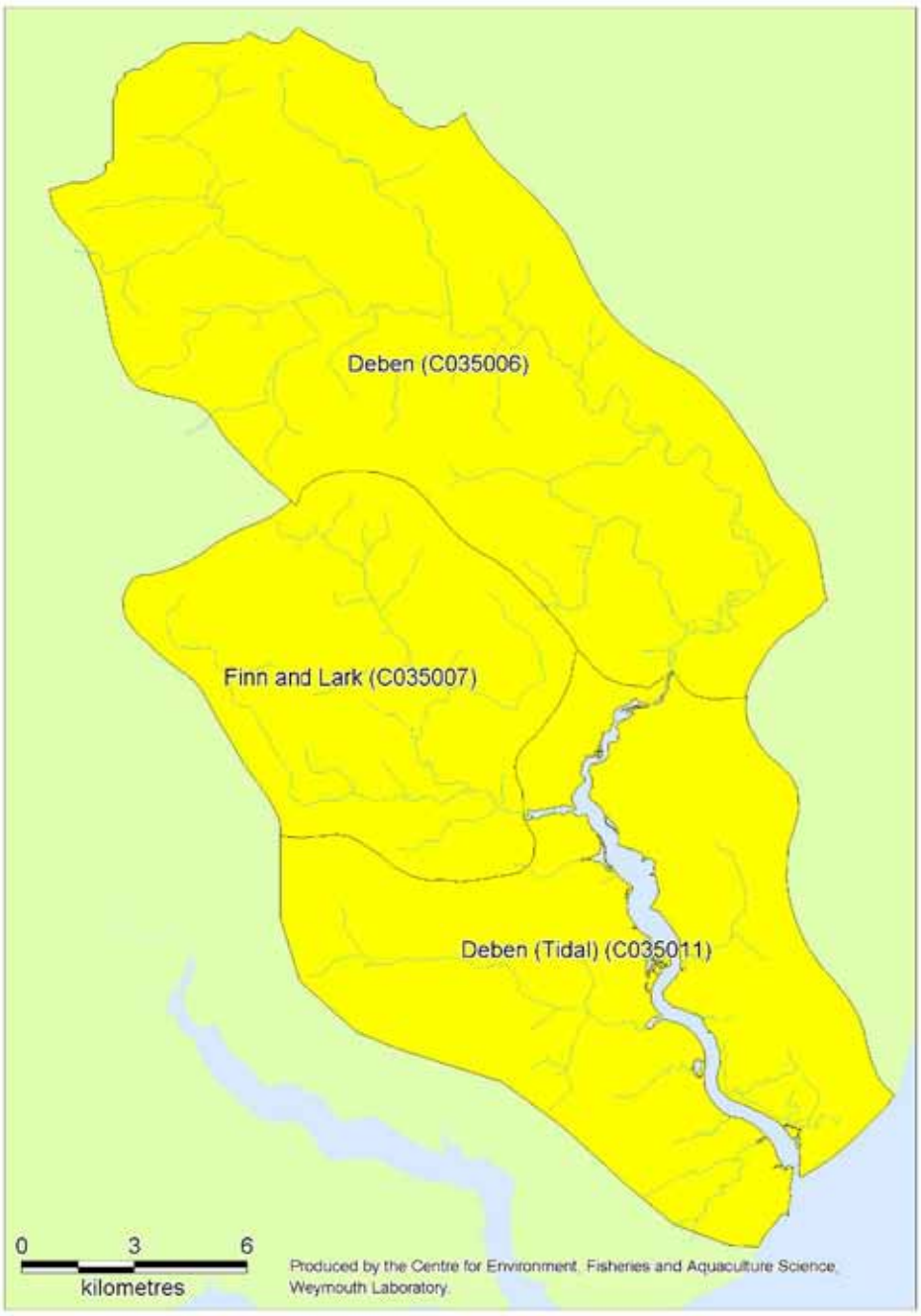

Figure VII.1 Location of catchments for agricultural survey data

Cattle and sheep are also present but at low densities. The overall density of grazers is only 20 animals/km^2 compared to a human population density of 138 people/km^2. Of potential local significance to the fishery is an area of pasture bordering Shottisham Creek, on which about 20 cattle are grazed from spring through to autumn (J. Simper, pers comm). No livestock was recorded in the immediate vicinity of the shore during the shoreline survey. Grazing animals (sheep and cattle) will directly deposit faeces on pastures, although during the winter cattle may be housed indoors and at these times slurry is collected and stored for later application to fields. Timing of cattle slurry applications is uncertain, although farms without large storage capacities are likely to spread

during the winter and spring. Numbers of grazing animals are expected to peak following the birth of lambs and calves in the spring, then decline in the autumn as these animals are sent to market. Therefore it is likely that peak levels of contamination from cattle and sheep 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 at a more localised level if wet weather occurs following a slurry application, and this may be most likely in the winter or spring for cattle operations.

In conclusion, most if not all significant watercourses draining to the Deben estuary are likely to be impacted by contamination from agricultural sources at times. The majority of livestock is farmed within the two subcatchments draining to the head of the estuary, so the largest part of contamination of livestock origin would enter the estuary here. A major source in terms of volume is the sporadic but widespread application of pig and poultry manures to arable land, the seasonal profile of which is uncertain. The presence of grazing animals on pastures may be of significance to some watercourses, notably Shottisham Creek, which discharges just south of Girlings Hard. Contamination from agricultural sources will be carried into the estuary by land runoff, so increased inputs will be associated with high rainfall events.

APPENDIX IX
SOURCES AND VARIATION AND MICROBIOLOGICAL POLLUTION: BOATS

Boat traffic within the Deben estuary is mainly limited to pleasure craft such as yachts, although there are a few small fishing vessels operating from Felixstowe Ferry, and water-skiers and canoeists also use the estuary. The boats most likely to make overboard discharges are yachts in overnight occupation on moorings, and it is also quite likely that the crew of transiting yachts use their onboard facilities in the relative calm of the estuary. There are areas of swinging moorings at Felixstowe Ferry, Ramsholt, Waldringfield and Woodbridge, with about 1,200 moorings in total (Environment Agency, 2010). There is also a 300 berth marina at Woodbridge, and sailing clubs at Felixstowe Ferry, Bawdsey, Waldringfield, with two at Woodbridge. There are no pump-out facilities within the Deben. At the time of shoreline survey about 70 small craft (cabin cruisers, fishing vessels and small yachts) were recorded on moorings at Felixstowe Ferry, 16 larger yachts were seen at Ramsholt, and 20 yachts and cabin cruisers were seen at Waldringfield. The Woodbridge area was not surveyed. A large proportion of moorings were unoccupied at the time, and as the survey was carried out in late November it is likely that most yachts were in storage on land. During the summer much higher numbers of yachts on moorings are anticipated. Satellite imagery taken during the summer showed considerably higher numbers of occupied moorings – around 150 at Felixstowe Ferry, around 100 at Ramsholt, around 120 at Waldringfield and around 160 at Woodbridge.

There are 220 moorings between Spinny Marsh and Methersgate, most of which may be occupied during the peak summer season. The main concentration of these is at Waldringfield. There are also anchorages just south of Shottisham Creek, where 10 yachts may be anchored at peak times. Therefore, yachts are likely to be in relatively close proximity to the fishery, at least during the summer months when there are more in the estuary. Negligible numbers of craft are in overnight occupation here during the winter, and no more than 30% (i.e. about 60 yachts) may be in overnight occupation at peak times during the summer (J. Smith, Waldringfield Harbour Master, personal communication).

In summary, overboard discharges of untreated sewage are likely to be made regularly within the estuary, mainly during the summer months. There are significant areas of swinging moorings in relatively close proximity to the fishery at Ramsholt, about 2.5km south, and at Waldringfield, where the main concentration is about 1.5km north, but the moorings and anchorages here do extend to and past the fishery area. It is likely that overboard discharges are also made by vessels on passage, potentially in close proximity to the fishery. Therefore, the fishery is likely to be impacted by overboard discharges from boats, which may occur anywhere in the vicinity of the fishery, but may be most frequent at Waldringfield. There will be a strong seasonality to these impacts, which are anticipated to be negligible during the winter and potentially quite significant to the fishery during the summer.

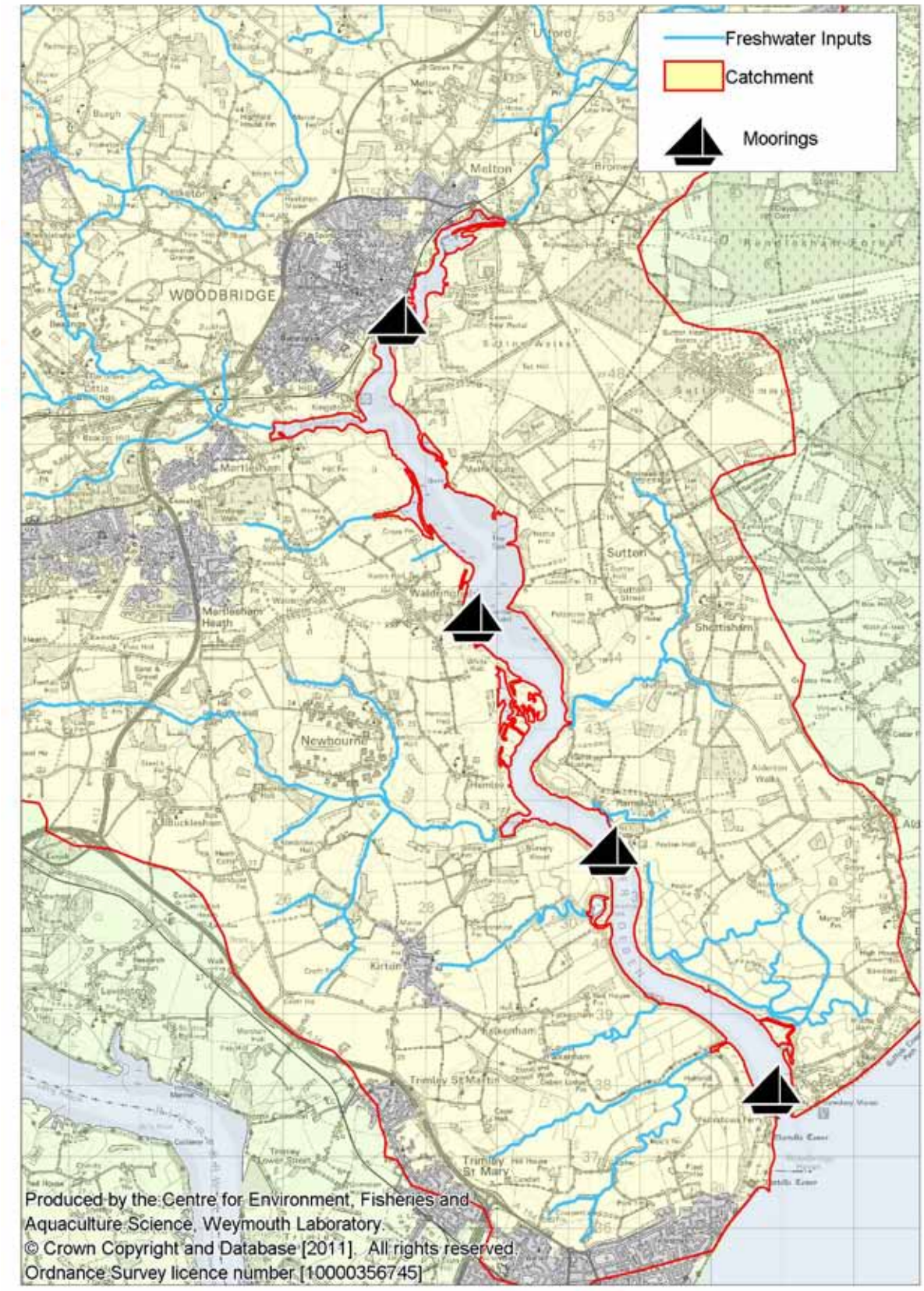

Figure IX.1 Main areas of moorings within the Deben estuary.

APPENDIX X
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: WILDLIFE

The Deben estuary is flanked by significant areas of saltmarsh and mud flats, which support significant populations of overwintering wildfowl and waders. The last reported Wetland Bird Survey (WEBS) low tide counts were undertaken at the Deben estuary over the winter of 2006/7 each month from November to February. A total of just over 17,000 wildfowl and waders were recorded overwintering within the Deben in 2006/7. Table X.1 presents peak and average total counts for the more numerous species during this period (Austin *et al*, 2008).

Species	Peak count	Mean Count
Bar-tailed Godwit	6	3
Black-tailed Godwit	177	157
Brent Goose	2,073	891
Curlew	451	361
Dunlin	3,500	2,554
Golden Plover	918	464
Grey Plover	223	167
Knot	204	99
Lapwing	2,315	1,339
Mallard	178	121
Oystercatcher	319	213
Pintail	296	169
Redshank	1,431	1,321
Ringed Plover	33	21
Shelduck	616	471
Teal	253	159
Turnstone	61	57
Wigeon	1,524	895

Of these birds, some species may remain in the area throughout the year, but the majority are likely to migrate elsewhere to breed. The Seabird 2000 survey carried out counts of breeding seabirds (gulls, cormorants, etc) during the early summer of 2000 (Mitchell *et al*, 2004). Only four breeding pairs of terns were recorded within the estuary during this survey, which indicates that there are not major breeding aggregations of gulls and other seabirds here. During the shoreline survey, which was undertaken during the late autumn, wading birds were seen regularly on the intertidal mudflats, and large numbers of ducks and geese were seen in flight over the estuary at dusk. Therefore some impacts may be expected from birds, particularly waders which may forage in very close proximity to the fishery. Spatially any impacts are likely to be diffuse and unpredictable, but highest in the winter.

There are significant colonies of both grey and harbour seals on the Norfolk coast at the Wash, Blakeney and Scroby Sands. The Sea Mammal Research Unit reported a total count of 299 harbour seals in Essex, Suffolk and Kent

(SMRU, 2009). It is possible that there are other more minor seal colonies closer to the Deben estuary. Therefore, seals may frequent the estuary from time to time, but not in large numbers, and so their impacts on the fishery, if any, are anticipated to be very minor, and not predictable either spatially or temporally.

No other wildlife populations which may have a potentially significant influence on levels of contamination within shellfish in the Deben estuary have been identified.

APPENDIX XI
MICROBIOLOGICAL DATA: WATER

BATHING WATERS

There are no bathing waters sites within the Deben estuary designated under the Bathing Waters Directive, nor does the estuary coincide with any Shellfish Growing Waters designated under the Shellfish Water Directive. The Environment Agency advised that no microbiological water quality surveys have been undertaken within the Deben estuary in recent years.

APPENDIX XII
MICROBIOLOGICAL DATA: SHELLFISH FLESH

12 mussel samples and 4 cockle samples taken by the LEA in the vicinity of Waldringfield and Methersgate in the early 1990s, but as these were taken almost two decades ago, the results are of little relevance to the current situation. The authors are not aware of any microbiological testing of shellfish flesh under any other programmes or projects within the Deben estuary.

APPENDIX XIII
MICROBIOLOGICAL DATA: BACTERIOLOGICAL SURVEY

After an initial review of information compiled for the desk study and a shoreline survey, the location of three potential monitoring points within the area requiring classification were identified. It was recommended that these points should be sampled on 10 occasions not less than a week apart, and unless the final sanitary assessment identified otherwise, the results of these could form part of the preliminary monitoring towards classification of this area. Only Pacific oysters have been sampled to date.

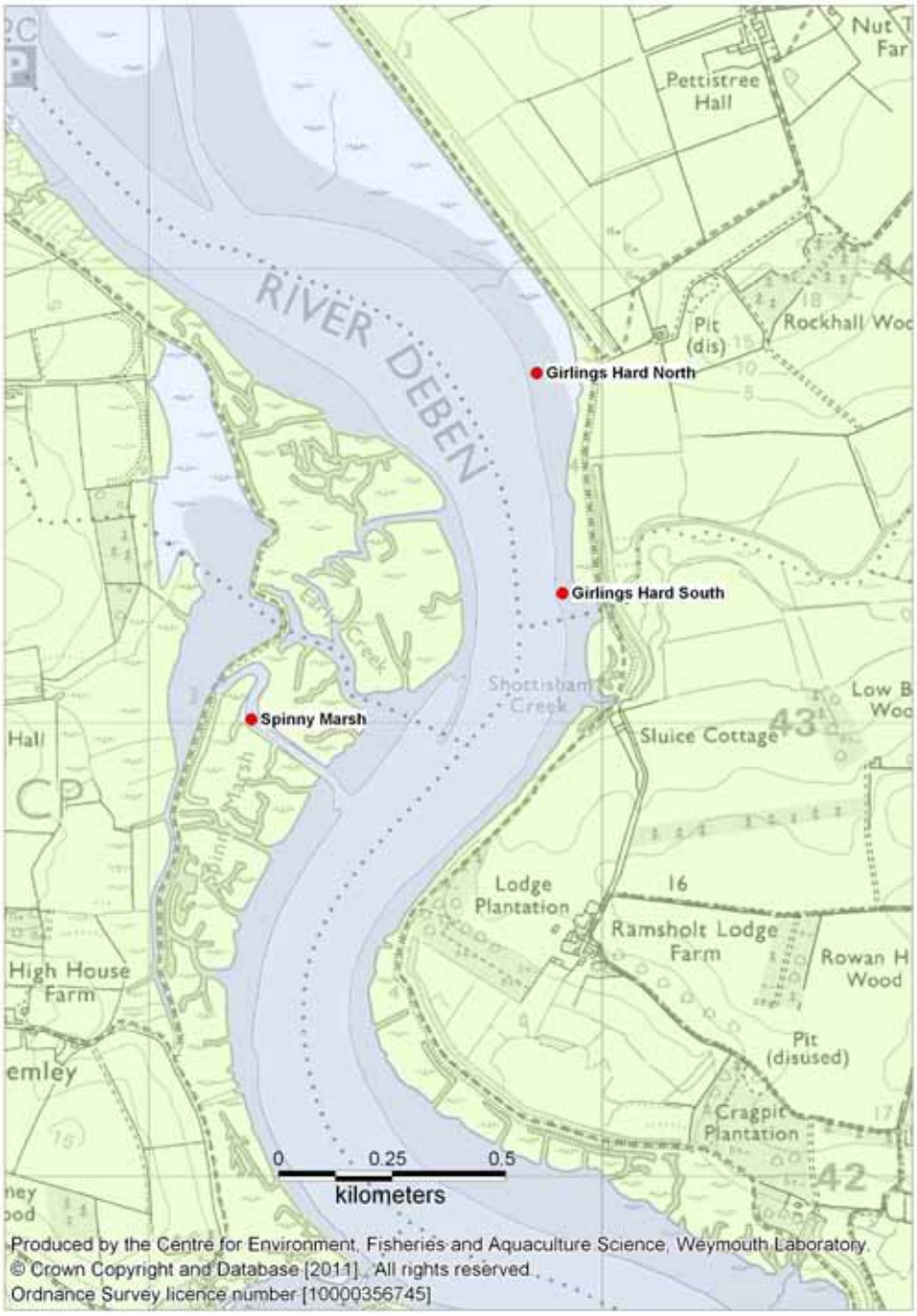

Figure XIII.1 Bacteriological survey points

Table XIII.1 presents the results of the bacteriological survey, and the same data is presented as a boxplot in Figure XIII.2.

Table XIII.1.* E. coli *results (MPN/100g) of Pacific oyster samples from the bacteriological survey

Site name	Girlings Hard North	Girlings Hard South	Spinny Marsh
NGR	TM 2986 4377	TM 2991 4328	TM 2923 4301
03-Feb-11	50	110	110
10-Feb-11	330	50	230
17-Feb-11	220	50	330
03-Mar-11	490	80	230
10-Mar-11	130	50	130
24-Mar-11	40	50	130
31-Mar-11	50	110	790
07-Apr-11	20	80	130
14-Apr-11	<20	<20	330
05-May-11	170	<20	20
Geometric mean	83	47	171
% exceeding 230	20%	0%	30%
Maximum	490	110	790

Results were fairly similar between sites. On average, levels of contamination were highest at Spinny Marsh, and lowest at Girlings Hard South. The highest proportion of results exceeding 230 *E. coli* MPN/100g and the highest individual result was recorded at Spinny Marsh. At Girlings Hard South no results exceeded 230 *E. coli* MPN/100g. It must be noted that these results only cover a limited period of the year, and significant seasonal fluctuations in *E. coli* levels are commonly observed within bivalves, the pattern of which will be largely dependent on seasonal variation in sources and fluxes of contamination.

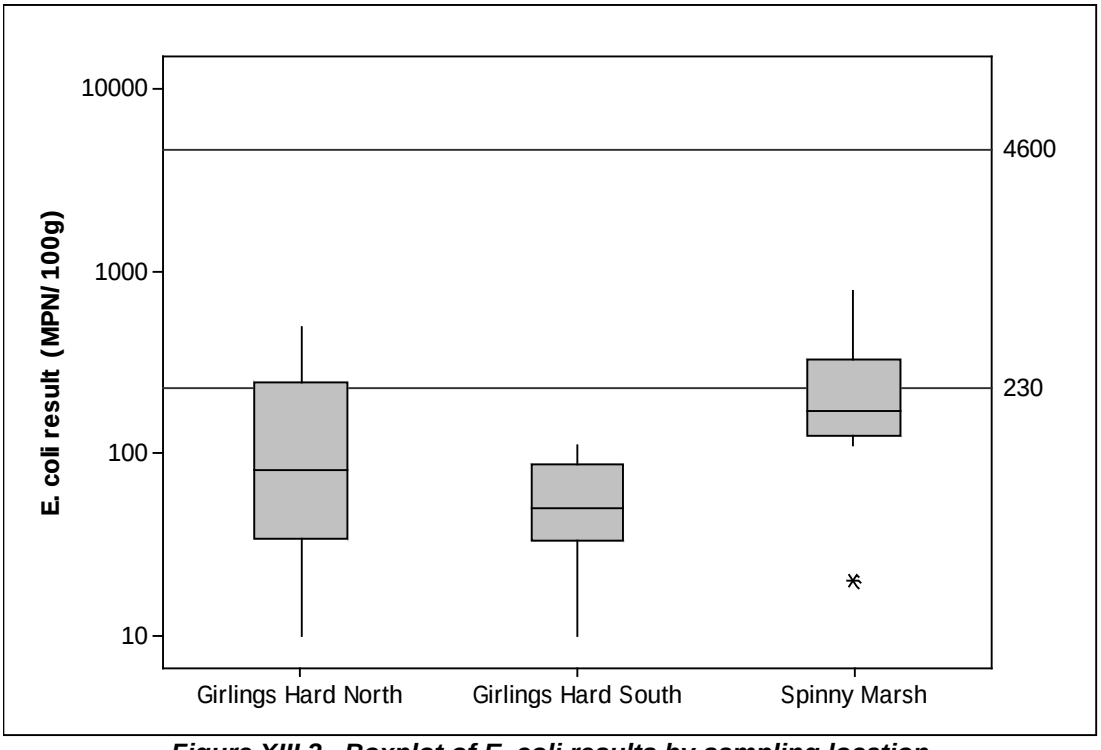

Figure XIII.2. Boxplot of E. coli results by sampling location

Despite the relatively small number of samples, a statistically significant difference was found between the sites (2-way ANOVA, p=0.028) but not sampling date (2-way ANOVA, p=0.260) indicating greater spatial than temporal variation within the results. A post ANOVA test (Tukey's comparison) indicated that results for Spinny Marsh were significantly higher than those at Girlings Hard South. The spatial patterns in *E. coli* levels observed in oysters are likely to follow a similar profile in other species.

APPENDIX XIV
SHORELINE SURVEY

Date (time): 29 November 2010 (14:30-16:15 GMT) and 30 November (08:00-12:30 GMT)

Applicant: Mr J. Simper (Simper Farms) (30 November)

Cefas Officers: Simon Kershaw, Alastair Cook

Local Enforcement Authority Officer: Mike Lavender (Suffolk Coastal District Council) (29 November).

Area surveyed: Deben Estuary (Figure XIV.1).

Weather: 29th November – winds SE force 4, 4°C, broken cloud
30th November – winds E force 6, 2°C, snow/hail showers

Tidal predictions (Woodbridge):
Admiralty TotalTide - 0134A Woodbridge 52°05'N 1°19'E England. Times GMT+0000. Predictions are based on WALTON-ON-THE-NAZE

29/11/2010		30/11/2010	
High	05:09 3.4 m	High	06:15 3.4 m
Low	11:22 0.6 m	Low	12:44 0.6 m
High	17:55 3.4 m	High	19:00 3.4 m
Low	23:33 1.0 m		

Predicted heights are in metres above Chart Datum

Objectives: (a) establish the geographical extent of the fishery and its *modi operandi*; (b) obtain samples of shellfish, seawater and freshwater inputs to the bay for bacteriological testing; and (c) identify any additional sources of contamination in the area. A full list of recorded observations is presented in Table 1 and the locations of these observations are mapped in Figure XIV.1. Photographs referenced in the text are presented in Figures XIV.4 - 7.

Description of Fishery

At the time of survey there are only wild stocks present. The area to be exploited is the intertidal area on the east bank of the estuary just to the north of Shottisham Creek (Girlings Hard, Figures XIV.1 and XIV.4), an area of about 1.25km^2. Wild Pacific oysters of a range of sizes were present indicating regular recruitment to the population. Densities varied, with some parts supporting up to 4 animals per m^2. Mussels and cockles were also present here. The harvester is primarily interested in the Pacific oysters due to the current favourable market for this species, with the cockles and mussels of secondary importance. Commercial scale exploitation within this relatively small area is likely to result in rapid depletion of these stocks.

In the longer term, the culture of Pacific oysters is planned. The preferred site is within the intertidal area at Girlings Hard. A Crown Estates lease would be required to grow oysters on trestles here, and whilst there are no reasons in principle for a lease not to be granted, negotiations are yet to be concluded. Here oysters would be grown on from seed on trestles, and the presence of wild stocks suggests that this area is favourable for culture of this species. A second oyster site is planned in a creek within Spinny Marsh, on the opposite bank (Figure XIII.5). A lease would not be required here. Oysters would be grown from seed in bags suspended from floats. The grower advises that oysters have been successfully cultured using this system in this location in the past. The grower plans to establish a depuration plant once the fishery has been sufficiently developed.

Elsewhere in the estuary, some other mussel beds were seen. Small numbers of oysters were observed on one of these but not at anywhere near the densities present at Girlings Hard.

Sources of contamination

The nearest potential source of contamination in the vicinity of the shellfishery is Shottisham Creek, at the south end of Girlings Hard. It was not possible to undertake a spot flow gauging of this watercourse. There are no significant freshwater inputs to the creek in Spinny Marsh on the opposite bank. The majority of surrounding land is used for arable farming.

The nearest settlement to the fishery is the village of Waldringfield, about 1.5km to the north of the fishery. One pipe was found on the shore here which was confirmed as a surface water rather than sewage outfall (Figures XIV.6 & XIV.7).

There is significant boating activity within the estuary. Areas of swinging moorings were observed at Felixstowe Ferry (70 small fishing vessels, cabin cruisers and yachts), Ramsholt (16 large yachts), Waldringfield (20 yachts and cabin cruisers). There is also a concentration of yachting facilities at Woodbridge, at the head of the estuary but this area was not surveyed.

A flock of wading birds was observed on the intertidal mud near Ramsholt, and small groups of these were regularly seen, so these constitute a potential source of contamination, particularly if they forage on the shellfish beds. Large numbers of wildfowl (ducks) were seen in the air over the estuary, and it is likely that they were returning to roost somewhere nearby, so these may also constitute a diffuse source of contamination.

Sample results

A full list of sample results is presented in Table XIV.2 and the locations of the sites sampled are mapped in Figure XIV.2. Due to the poor weather conditions, Royal Mail were unable to deliver the samples to the lab until 3 days after they were collected, so some bacterial die-off may have occurred, and the shellfish testing results from this survey cannot be used for classification purposes. Both

shellfish and water sample results indicated higher levels of contamination in the upper reaches of the estuary north of Waldringfield. Shellfish samples taken at Girlings Hard returned a mixture of class A and low class B results, and results were similar at either end of this beach. A seawater sample taken at the mouth of Shottisham Creek did not suggest this watercourse creates a hotspot of contamination at the south end of Girlings Hard.

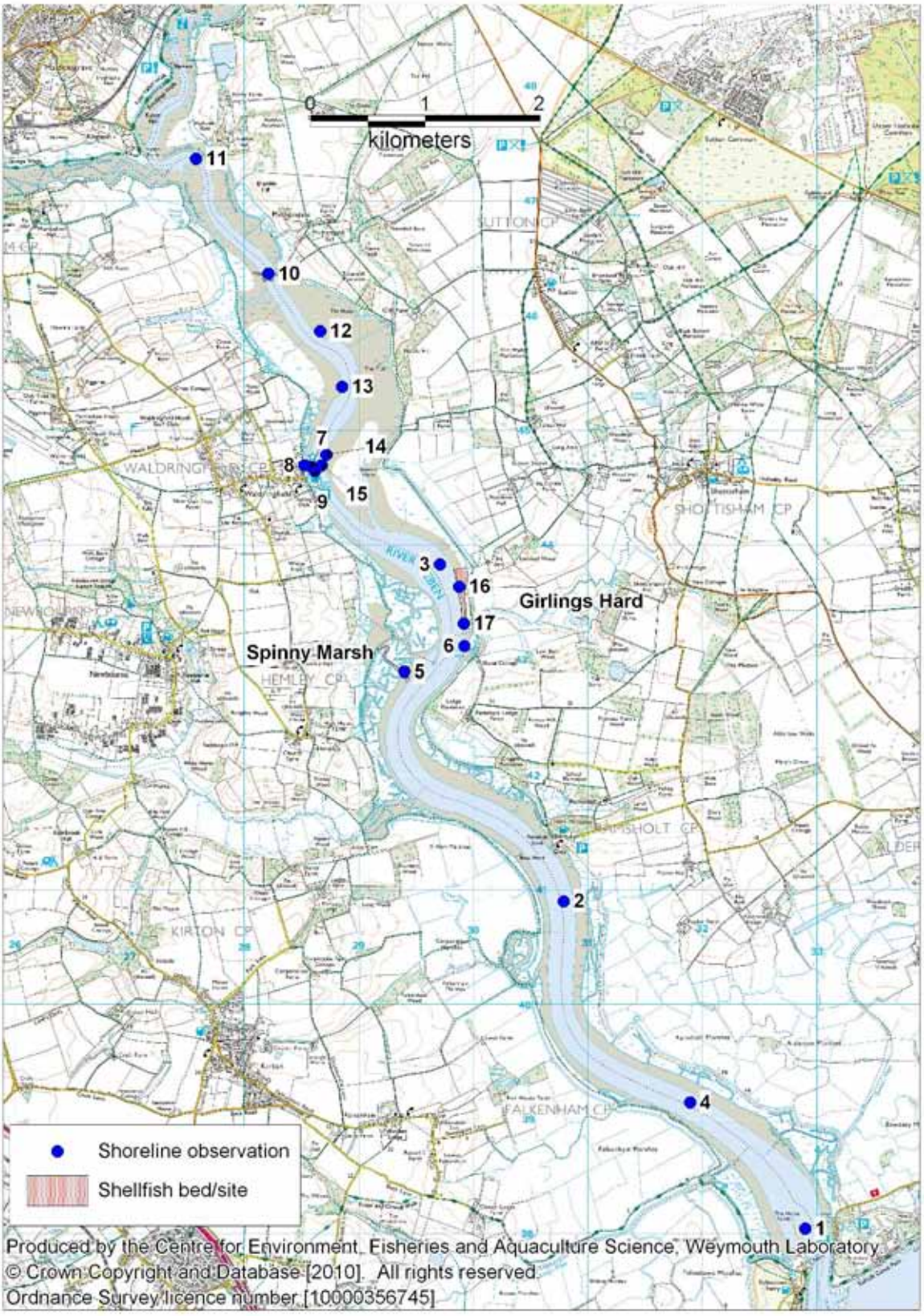

Figure XIV.1. Locations of shoreline observations

Table XIII.1. Details of shoreline observations

No.	Date & Time	Position	Details
1	29-NOV-10 15:03	TM 32896 38042	Moorings at Felixstowe Ferry. About 70 small craft (yachts, fishing vessels, dinghies and small cabin cruisers)
2	29-NOV-10 15:14	TM 30789 40898	Moorings mostly unoccupied, 16 larger yachts
3	29-NOV-10 15:28	TM 29706 43830	~100 waders disturbed from Ramsholt side
4	29-NOV-10 15:54	TM 31893 39143	Several hundred ducks flying overhead heading to roost
5	30-NOV-10 09:06	TM 29397 42897	Water sample 1 from mouth of creek at Spinny Marsh where oysters will be grown. 27ppt, 2.5^{0}C.
6	30-NOV-10 09:15	TM 29918 43118	Water sample 2. 27.3ppt, 2.5^{0}C.
7	30-NOV-10 09:31	TM 28589 44681	20 boats on moorings at Waldringfield
8	30-NOV-10 09:38	TM 28525 44694	Pipe across shore (EA sluice so freshwater rather than foul water)
9	30-NOV-10 09:50	TM 28613 44643	Water sample 3. Buoy 1A. 25.7ppt and 2.5^{0}C (top), 25.9ppt and 2.5^{0}C (3m)
10	30-NOV-10 10:04	TM 28210 46366	Water sample 4. 22.0ppt and 2C (top), 24.3ppt and 2.1C (3m). 6 yachts on moorings.
11	30-NOV-10 10:16	TM 27578 47369	Water sample 5. 19.9ppt and 1.8^{0}C (top) and 19.9ppt and 1.9^{0}C (3m)
12	30-NOV-10 10:46	TM 28662 45866	Mussel sample 1. Mussel bed, but very few Pacific oysters here.
13	30-NOV-10 10:58	TM 28854 45380	Small mussel bed on east bank
14	30-NOV-10 11:05	TM 28716 44789	Mussel bed on east bank
15	30-NOV-10 11:06	TM 28676 44694	Mussel bed on east bank
16	30-NOV-10 11:27	TM 29876 43637	Mussel sample 2 and oyster sample 1. North end of wild oyster and potential future trestle site.
17	30-NOV-10 11:59	TM 29916 43316	Mussel sample 3 and oyster sample 2. South end of wild oyster and potential future trestle site.

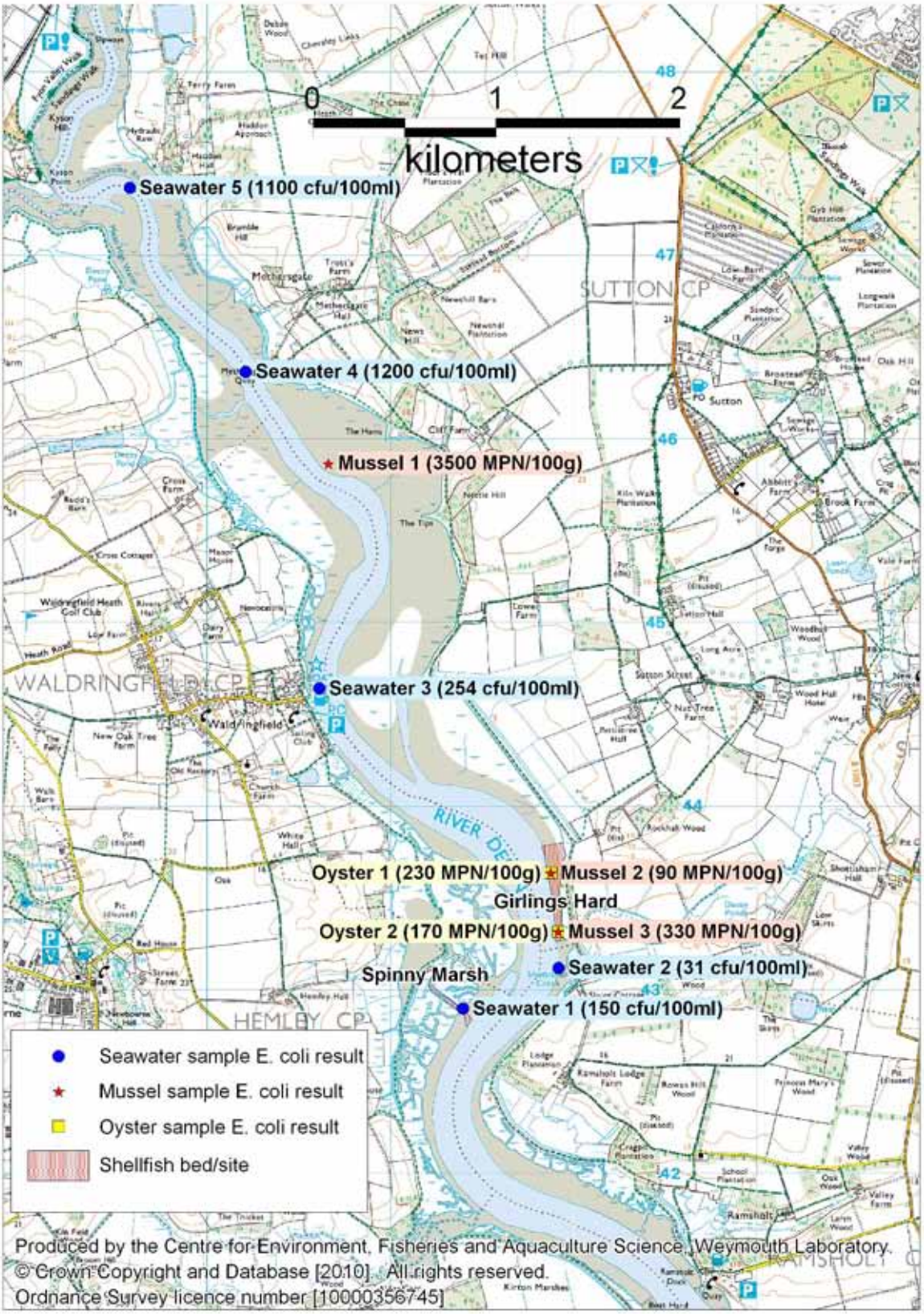

Figure XIV.2. Locations of samples taken

Table XIII.2. Details of samples taken

Sample	Date & Time	Position	*E. coli**
Seawater 1	30-NOV-10 09:06	TM 29397 42897	150
Seawater 2	30-NOV-10 09:15	TM 29918 43118	31
Seawater 3	30-NOV-10 09:50	TM 28613 44643	254
Seawater 4	30-NOV-10 10:04	TM 28210 46366	1,200
Seawater 5	30-NOV-10 10:16	TM 27578 47369	1,100
Mussel 1	30-NOV-10 10:46	TM 28662 45866	3,500
Mussel 2	30-NOV-10 11:27	TM 29876 43637	90
Mussel 3	30-NOV-10 11:59	TM 29916 43316	330
Oyster 1	30-NOV-10 11:27	TM 29876 43637	230
Oyster 2	30-NOV-10 11:59	TM 29916 43316	170

*Water sample results are reported in cfu/100ml and shellfish sample results are reported in MPN/100g.

Conclusions

There are two discrete sites which require classification, one at Spinny Marsh where pacific oysters are to be grown from bags suspended from floats, and one on the opposite bank of the estuary at Girlings Hard where wild Pacific oysters, mussels and cockles are to be harvested, and Pacific oysters are to be grown on trestles. At Girlings Hard the required lease for the trestles is yet to be granted, and the wild stocks are likely to be exhausted fairly rapidly if harvested on a commercial scale.

Only one local source of contamination which may cause a noticeable spatial variation across Girlings Hard was identified – a freshwater input (Shottisham Creek) to the southern end of this. Samples taken during the survey did not suggest that this source created a hotspot of contamination at its mouth. No sources of contamination were recorded within the creek at Spinny Marsh or to the west bank of the estuary within 1km. The closest source to the west bank is Kirton Creek, just over 1km to the south.

On a wider scale, sample results showed an increasing level of contamination towards the head of the estuary. This is not surprising as the main River Deben discharges here and there are several sewage discharges associated with the town of Woodbridge.

Significant numbers of yachts and other small craft use the estuary, and these may constitute a significant source of contamination during the summer months when there will be more on the water and occupancy will be highest. Significant areas of moorings were recorded at Felixstowe Ferry, Ramsholt and Waldringfield. Whilst seasonal variation in the significance of yachts is anticipated, it is not thought that these will cause any consistent or predictable spatial variation in levels of contamination at the fishery.

Waders and wildfowl are likely to be present in significant numbers in the area, with numbers likely to be the highest in winter. It is likely that at times they forage in very close proximity to the fishery so may be a significant contaminating influence. However, as these constitute a diffuse source of contamination it is not thought that these will cause any consistent or predictable spatial variation in levels of contamination at the fishery.

Circulation within the estuary is likely to be dominated by tidal forces, with water flowing north on the flood and south on the ebb. This is likely to be the pattern observed at Girlings Hard, although the harvester indicated that an eddy sometimes forms by the mouth of Shottisham Creek. The creek at Spinny Marsh will gradually fill on the flood, and drain on the ebb so in the absence of sources direct to this creek, any sources to the west bank of the estuary to the south of the fishery may have the greatest impacts.

Figure XIV.4 – Intertidal shellfish beds at Girlings Hard

Figure XIV.5 – Creek at Spinny Marsh

Figure XIV.6 – Surface outfall pipe at Waldringfield

Figure XIV.7 – Signage associated with pipe shown in Figure XIV.6

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List of Abbreviations

AONB	Area of Outstanding Natural Beauty
BMPA	Bivalve Mollusc Production Area
CD	Chart Datum
Cefas	Centre for Environment Fisheries & Aquaculture Science
CFU	Colony Forming Units
CSO	Combined Sewer Overflow
CZ	Classification Zone
Defra	Department for Environment, Food and Rural Affairs
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
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
OSGB36	Ordnance Survey Great Britain 1936
mtDNA	Mitochondrial DNA
PS	Pumping Station
RMP	Representative Monitoring Point
SAC	Special Area of Conservation
SSSI	Site of Special Scientific Interest
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. Ebb-dominant estuaries have asymmetric tidal currents with a shorter ebb phase with higher speeds and a longer flood phase with lower speeds. In general, ebb-dominant estuaries have an amplitude of tidal range to mean depth ratio of less than 0.2.
EC Directive	Community legislation as set out in Article 189 of the Treaty of Rome. Directives are binding but set out only the results to be achieved leaving the methods of implementation to Member States, although a Directive will specify a date by which formal implementation is required.
EC Regulation	Body of European Union law involved in the regulation of state support to commercial industries, and of certain industry sectors and public services.
Emergency Overflow	A system for allowing the discharge of sewage (usually crude) from a sewer system or sewage treatment works in the case of equipment failure.
Escherichia coli (*E. coli*)	A species of bacterium that is a member of the faecal coliform group (see below). It is more specifically associated with the intestines of warm-blooded animals and birds than other members of the faecal coliform group.
E. coli O157	E. *coli* O157 is one of hundreds of strains of the bacterium *Escherichia coli*. Although most strains are harmless, this strain produces a powerful toxin that can cause severe illness. The strain O157:H7 has been found in the intestines of healthy cattle, deer, goats and sheep.
Faecal coliforms	A group of bacteria found in faeces and used as a parameter in the Hygiene Regulations, Shellfish and Bathing Water Directives, *E. coli* is the most common example of faecal coliform. Coliforms (see above) which can produce their characteristic reactions (e.g. production of acid from lactose) at 44°C as well as 37°C. Usually, but not exclusively, associated with the intestines of warm-blooded animals and birds.
Flood tide	The rising tide, immediately following the period of low water and

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

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