Hertfordshire and North London

Fisheries Monitoring Summary Report 2015

Ben Radbone, Sampling and Collection Team

January 2016

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Environment Agency
Horizon house, Deanery Road,
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Email: enquiries@environment-agency.gov.uk
www.gov.uk/environment-agency

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T: 03708 506506

Email: enquiries@environment-agency.gov.uk.

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Introduction

The rivers and waterways that flow through Hertfordshire and North London provide anglers with a diverse array of excellent angling opportunities. Be it the specimen barbel and chub found within the waters of the River Lee or River Colne, pleasure or match fishing for roach on the Lee Navigation, or game fishing for brown trout and grayling found within tributaries such as the Chess, Mimram, Rib and Ash, these rivers support a rich diversity of plant and animal fauna of considerable conservation value, and provide a valuable socio-economic resource.

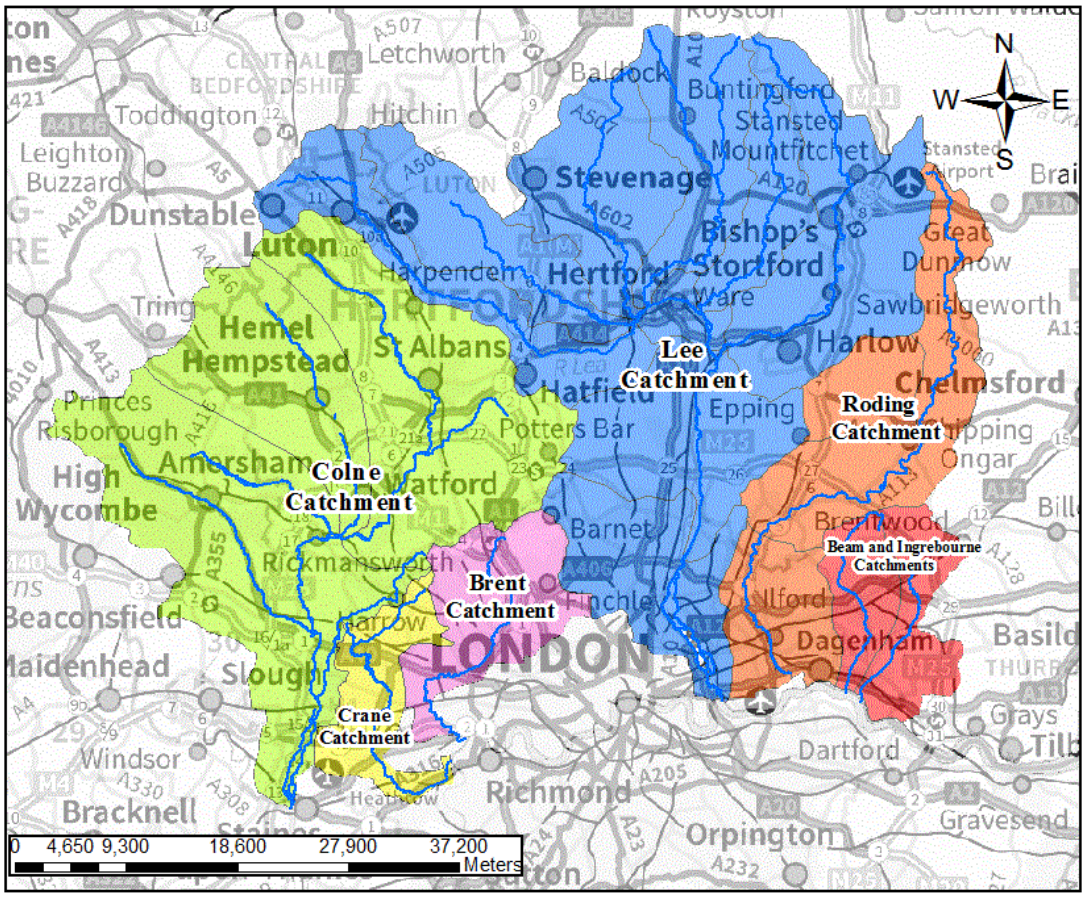

Figure 1.1: Major river catchments within the Environment Agency Hertfordshire and North London Area.

Under the Environment Act (1995) the Environment Agency has a statutory duty to maintain, improve and develop fisheries resources within England. An essential element of the Environment Agency's work towards achieving this aim involves monitoring the status of fish populations in order to determine if and how they are changing on both a temporal and spatial scale.

Accurate description of the current status and elucidation of possible long term trends based on fish population data collected by the Environment Agency can be key in informing fisheries management and in guiding actions taken in order to conserve, maintain and improve fisheries.

This report aims to provide an overview of fisheries monitoring undertaken by the Environment Agency in Hertfordshire and North London during the course of 2015, focusing

primarily on the results of National Fisheries Monitoring Programme and Water Framework Directive driven surveys, but also touching upon some of the locally driven investigative monitoring lead by the areas Fisheries team.

Why, what and how we monitor fish populations

The Environment Agency's fisheries monitoring programme is driven by scientific, business and legislative factors, and falls broadly within three elements:

National Fisheries Monitoring Programme monitoring (NFMP)

Initially devised in 2001 to meet the needs of the Fisheries function, the NFMP focuses primarily on those river fisheries which receive significant angling attention, with the aim of creating long term temporal and spatial data sets from which trends in fish populations may be detected.

Formed of two main elements; coarse monitoring and salmonid monitoring programmes, the frequency by which a river is monitored depends on its utilisation as an angling resource. Coarse fisheries are classified either as Principal Reference fisheries (surveyed annually), Principal Other fisheries (surveyed triennially) or General coarse fisheries (surveyed 6-yearly), whilst monitoring of Wild Brown Trout fisheries is carried out biennially. In Hertfordshire and North London the coarse element constitutes the majority of our NFMP monitoring (87%), with Wild Brown Trout fisheries on the Rivers Rib, Ash, Mimram and Chess making up the remainder.

Water Framework Directive Monitoring

The Water Framework Directive (WFD) is **the** key piece of European legislation governing how we manage water resources within the UK. It encompasses legislation including the Habitats Directive, Freshwater Fisheries Directive and Salmon and Freshwater Fisheries Act. Under the WFD the UK has an obligation to ensure all surface freshwater bodies reach good ecological status, or in the case of heavily modified water bodies good ecological potential, by 2027. Fish form an important element when assessing the ecological status of a water body, and are key biological indicators of the impact pressures such as sedimentation, morphological and hydrological alterations are having. Pressures highlighted as affecting fish populations within the course of this report are based on those identified during WFD risk assessments. Sites selected for WFD fish classification are surveyed once within a six yearly cycle.

Local Investigative monitoring

Where our core monitoring programme does not meet local needs additional investigative surveys may be conducted in order to provide the necessary data. This can include such things as appraisal of the efficacy of projects, or assessing the impact of pollution incidents on fish stocks.

Capture Techniques

Electric fishing: Electric fishing is the most common method of monitoring fish in small and medium-sized rivers, and was used as the method of surveying in 100% of surveys carried

out within the Hertfordshire and North London Area in 2015. It works by immersing into the river one or more electrodes connected to a power source and control box. The electric field created stuns the fish within the field and, by interfering with the fishes' swimming muscles, draws the fish towards the centre of the electrode. They are then removed from the water to be counted, measured, and in some cases weighed. A scale sample may be taken so that the age and growth history of the fish can be determined. To estimate the number, density and biomass of fish in a river, a reach is isolated using two nets strung across the river. This prevents fish moving into or out of the survey section.

Fishing the whole width of the river, working from the lower net to the upper net, fish are caught, counted, measured and then retained in suitable holding facilities until the survey is completed. In order to derive a quantitative population estimate the reach is fished once or twice more, and on each fishing 'run' the catch is removed, processed and retained. From these results it is possible to calculate an estimate for the total number of fish within the section. Water Framework Directive survey results are based on numbers of fish captured within a single electric fishing run. After the survey is complete, all captured fish are returned alive to the survey site.

Although electric fishing is very effective in many water bodies and for sampling certain fish populations, it does have limitations. It is relatively ineffective in larger, deeper rivers, canals and still waters. Although new equipment has been developed for sampling deeper water it remains difficult to obtain accurate estimates of fish numbers from larger water bodies by electric fishing alone. Also it is biased against the capture of smaller fish, due to this results from NFMP surveys used within this report in the main focus on captured fish >99mm in length, from which more accurate population estimates can be derived. WFD specific surveys focus on the presence of species within a survey, and as such all captured fish are reported in these instances.

Concerns have been expressed about the harm electric fishing can do to fish and fisheries, particularly where waters are surveyed repeatedly. Used inappropriately, electric fishing can indeed injure or even kill fish, and poor or excessive handling can also be harmful. Any such damage is kept to an absolute minimum by following recognised best practice, and by using highly trained staff. Electric fishing remains the most effective means of monitoring many fisheries.

Seine netting: on larger water bodies where width of river channel and depth of water limit the effectiveness of electric fishing as a survey technique, the use of seine netting can be an effective alternative in gaining fish population estimates.

As with electric fishing a stretch of river approximately 100m in length is isolated between two stop nets to prevent migration of fish into and out of the survey site. A large seine net deep enough to reach the river bed is then laid around the perimeter of the isolated section by boat and drawn slowly into the bank. Those fish species captured are counted, measured and then retained whilst subsequent nets are drawn in order to achieve a catch depletion from which a population estimate may be derived.

Sites where large undulations in river bed topography or large snags are present may be unsuitable as the bottom of the net may lift, or the net become damaged, enabling fish to

evade capture. The technique is not applicable where strong flows may be encountered preventing the net from effectively being set and drawn in.

The influence of hydro-climatic conditions on fish population dynamics

The National Fisheries Monitoring Programme was developed in order to create long term data sets that would enable trends within riverine fish populations to be effectively identified. Although surveys of individual sites provide a valuable insight into the status of a fishery at a local scale, by amalgamation of data from all sites surveyed within a catchment in a year underlying trends within populations are more readily identified when put into a temporal context.

Fluctuations in both density and biomass of fish species are to be expected within healthy riverine fisheries. Apparent decreasing productivity within a fishery may point to underlying pressures or stressors acting upon fish populations, in which case attempts may be made to address these through effective fishery management. Pressures risk assessed as being applicable to the fish populations of individual waterbodies as part of WFD classification are highlighted within this report. More commonly the primary drivers of such fluctuations are rooted in natural environmental variation.

The extent to which successful recruitment occurs within a population of fish in a given year, known as the Year Class Strength, has perhaps the greatest bearing on freshwater fish population dynamics (Chambers and Trippel, 1997). High mortality rates in young of year fish will translate into underrepresented year classes of adult fish. A multitude of biotic and abiotic interactions may potentially exert an influence on levels of recruitment within fish populations. The influence of biotic (i.e. density dependent inter-specific or intra-specific interactions) undoubtedly has a bearing on young of year survival rates, although the extent to which these factors contribute is difficult to quantify in natural river systems. The same can be said of many abiotic factors (i.e. chemical water quality, barriers to migration), however in river systems the effect of hydro-climatic events in particular are well documented as being key (Nunn et al, 2007).

The metabolism of fish as poikilothermic organisms is governed by the ambient temperature of their surrounding environment. Exceptionally warm years may produce particularly strong year classes, with increased metabolic function and feeding leading to increased growth rates. This is important in shaping strong year classes as larval fish which attain greater size correspondingly are capable of stronger, faster swimming. This is particularly important in increasing the resilience of young fish to hydrological events, with susceptibility to displacement decreasing with size (Harvey, 1987).

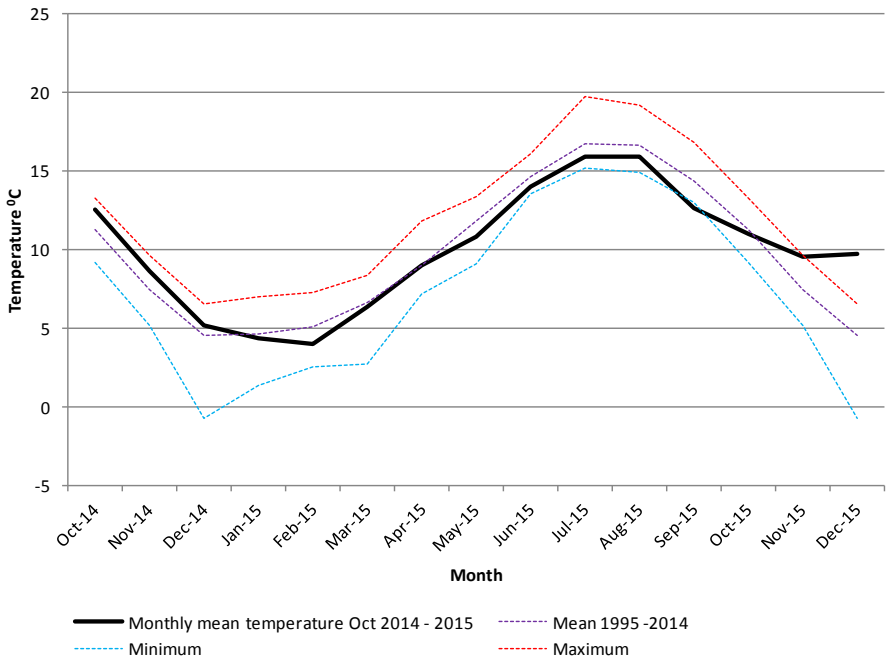

Figure 2.1: Monthly mean temperature October 2014 – December 2015 in comparison to the long term mean, maximum and minimum monthly mean temperatures in degrees Celsius for the period 1995 - 2014

Figure 2.1 details mean monthly temperatures for the period October 2014 to December 2015, with comparative long term mean values. The mild winter of 2014/15 precluded a cool summer with below average temperatures experienced between May and September. Heading into winter 2015 November and December were exceptionally mild. In fact December was the warmest on record in the Central England temperature series from 1659. The summer months provide the main period of significant growth for most fish species. Figure 2.2 shows cumulative degree days >12^{o}C for the United Kingdom between 1995 and 2015. This temperature is the threshold at which significant growth occurs within temperate cyprinid fishes (Nunn et al. 2003). The cool temperatures experienced during the majority of summer 2015 translate into the lowest number of cumulative degree days >12^{0}C across the time period 1995 to 2015. This is likely to result in a reduction in juvenile fish growth rates and ultimately play a part in shaping year class strength of fish spawned in 2015.

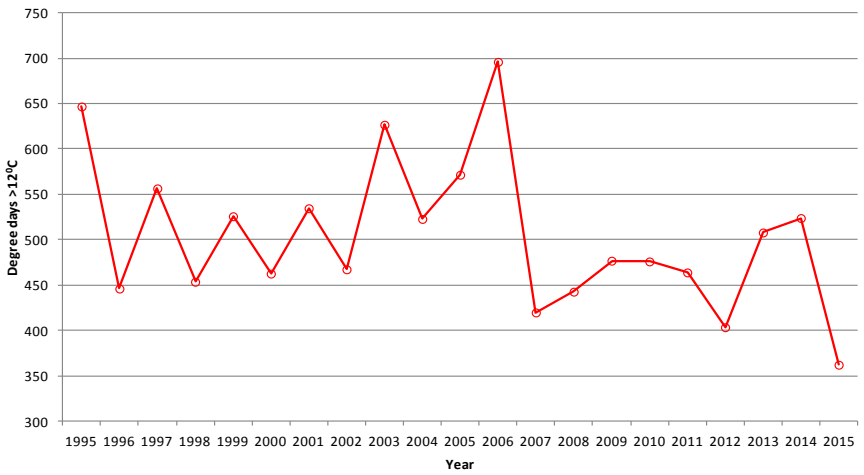

Figure 2.2: Yearly cumulative degree days >12^{0}C for the time period 1995 – 2015 (data from the Met Office Hadley Central England data centre)

In years where above average summer or winter river discharge is experienced survivorship of young of year fish may be adversely affected. Increased velocity of water within marginal habitat, such as emergent vegetation, which provides areas of low velocity or slack water that juvenile fish seek out, can lead to these fish becoming entrained and effectively 'washed out' and lost to a fishery. Flood events during the summer months in particular may have the greater effect, when larval fish still in the early stages of their development are less resilient to such perturbations.

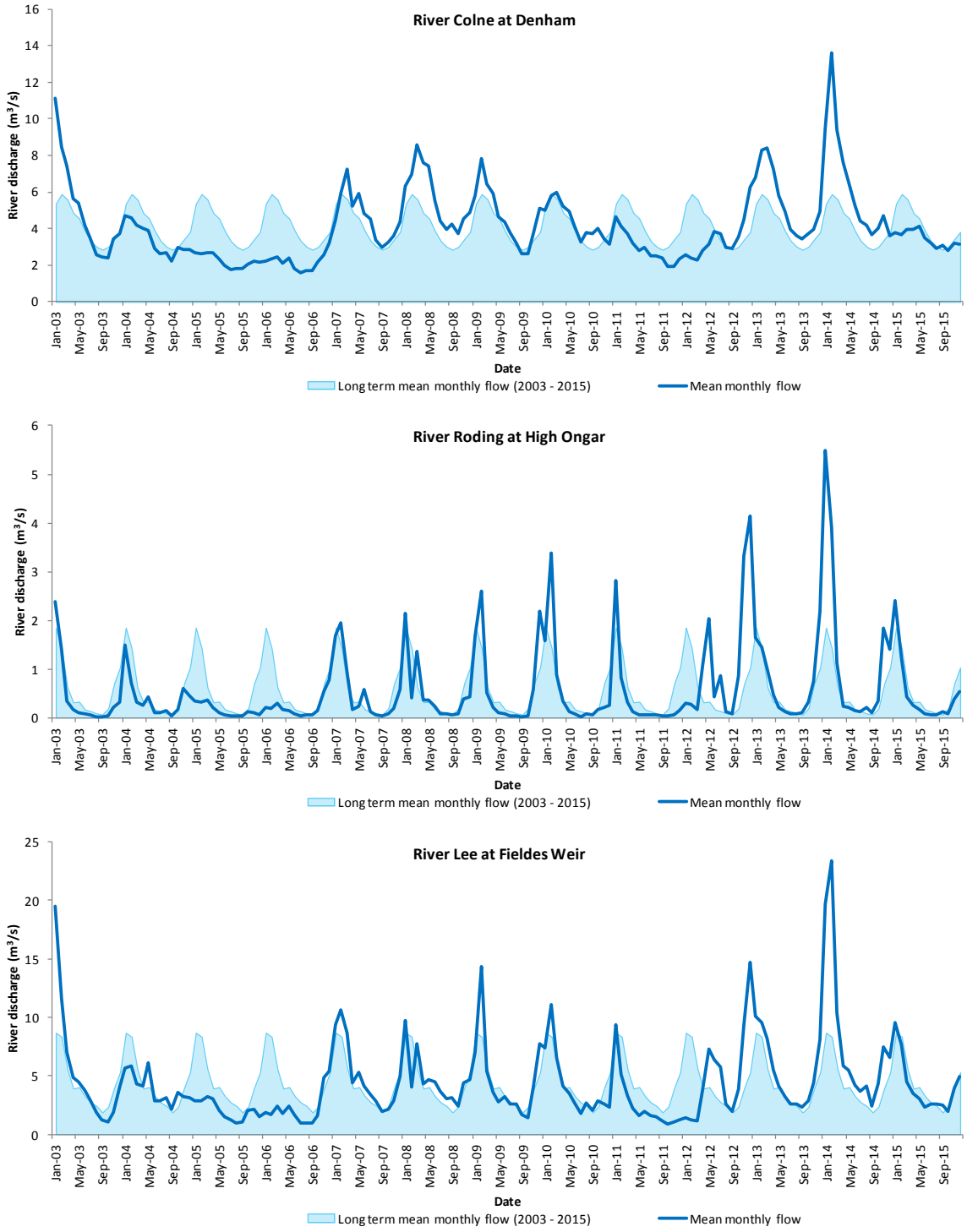

Figure 2.3: Mean monthly flows for three of the major rivers within the Hertfordshire and North London Area in comparison to the long term mean for the time period 2003 – 2014. (Data from Environment Agency Hydrometric gauging stations).

Flows experienced over winter 2014/15 were far removed from those experienced on the rivers of Hertfordshire and North London during the winter of 2013/14, when widespread flooding afflicted many catchments. Figure 2.3 details river discharge for three of the major rivers within the Hertfordshire and North London Area from January 2003 to December 2015. Heavy rainfall during autumn 2014 led to above average flows, with the highest October monthly mean river discharge for the time period 2003 – 2015 experienced on both the River Lee and the River Colne. The River Colne experienced particularly benign winter flows from December onwards, with low river discharge carrying on into the New Year and staying below the long term mean for the period December 2014 to August 2015. From February and on through until the late summer of 2015 flow was generally slightly below long term mean values for both the Lee and Roding. Calm hydrological conditions throughout the summer months are likely to facilitate increased survival amongst the progeny of 2015 spawning.

Looking back over the previous few years, hydro-climatic conditions experienced by young of year fish have been particularly adverse. The cool wet summer of 2012 and successive wet winters in 2012/13 and 2013/14 provided less than ideal conditions for the production of strong year classes. In 2014 a warmer summer meant that cumulative degree days $>12^0$C were the highest since 2006. The two successive wet winters preceding 2014 lead to significant recharge of the aquifer in many catchments, and gave rise to stable but elevated flows throughout the summer of 2014, particularly for those rivers formed over more permeable bedrock geology. Despite this the 2014 year class, as well as experiencing more favourable temperatures for juvenile development than during the preceding seven years, is likely to have benefitted from normal, or in the case of the River Colne below average, flows during their first winter which may have increased survival rates.

Levels of recruitment success over recent years will become clear in future surveys, and are not immediately obvious within results detailed in this report which focuses primarily on data for fish >99mm.

River Colne

Catchment overview

The source of the River Colne is North Mymms Park Hertfordshire, from where it flows past Colney Heath and London Colney. Near Bricket Wood it is joined by the first of its major tributaries the River Ver. Between Watford and Rickmansworth a further two major tributaries; the Rivers Gade and Chess, converge with the Colne. Downstream of Watford the Grand Union Canal runs parallel to, and occasionally interlinks with the River Colne. As we head further down the catchment a further major tributary, the River Misbourne, joins the Colne near Denham.

Below this point the course of the river becomes increasingly complex with interconnections between the Colne and the rivers Pinn, Frays, Wraysbury and Colnebrook, whilst water is also drawn from the Colne by three artificial rivers; the Duke of Northumberland, Ash and Longford. Geology of the catchment is chalk in the upper reaches, going into London clay below the Denham and Uxbridge area.

The River Colne flows for approximately 56km from source to its confluence with the River Thames at Staines, draining a catchment of approximately 1018km^2.

Figure 3.1: The River Colne at Drop Lane 2015

Water Framework Directive classifications

Waterbody	Fish	Invertebrates	Macrophytes and phytobenthos	Ammonia	Dissolved Oxygen	Phosphate
Colne (upper east arm including Mimshall Brook)	Bad	Not assessed	Poor	High	High	Moderate
Upper Colne and Ellen Brook	Not assessed	Moderate	Poor	High	Poor	Moderate
Colne (from confluence with Ver to Gade)	High	Good	Moderate	High	High	Poor
Colne (confluence with Chess to River Thames)	Moderate	High	Good	High	High	Poor

Table 1: Water Framework Directive classifications for fish and some of the key elements affecting fish populations within River Colne WFD waterbodies.

Main pressures affecting fish populations

Hydrology: Flow is impacted upon by significant groundwater abstraction, principally for the water industry.

Invasive non-native species: Both the North-American signal crayfish and the non-native macrophyte floating pennywort are widely distributed within the catchment. Non-native crayfish may compete for finite resources with fish species, and impact upon invertebrate communities which provide a food source for fish. Where present in high numbers they are also known to significantly alter the morphology of the river channel through burrowing, increasing bank erosion and sediment deposition. Floating pennywort may out-compete native aquatic plant species resulting in reduced species diversity and available habitat for fish species.

Morphology: Wide spread anthropogenic modification of the river channel and surrounding flood plain. This includes inland navigation, with the Grand Union Canal enveloping sections of the old river channel, structures created for agricultural and rural land management purposes, primarily in the upper reaches, and flood defence structures. These may impact upon fish populations through creation of barriers to migration, and by altering the rivers hydrological and sediment transportation characteristics.

Fishery survey results 2015

Five sites are surveyed annually and two triennially on the River Colne as part of the National Fisheries Monitoring Programme, all of which were surveyed in 2015. A further survey was conducted at Colney Heath for WFD classification purposes. A significant fish mortality incident affected the Colne between Watford and the point at which the Colne joins the GUC upstream of Rickmansworth in early July 2015. In response to this a further survey was conducted within the afflicted reach at Merchant Taylors in order to assess the impact.

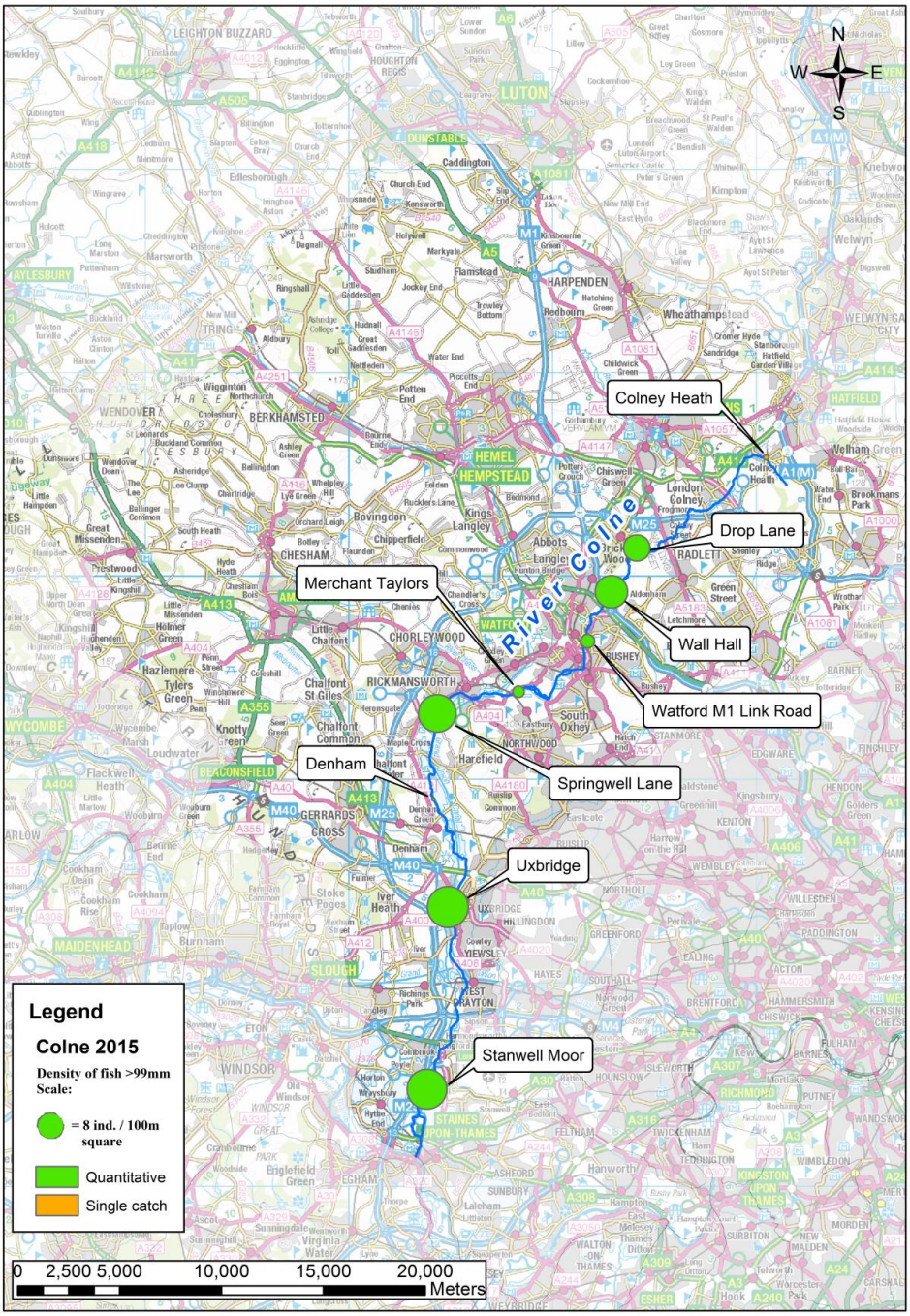

Figure 3.2: River Colne catchment showing location of survey sites, survey methodology and comparative estimated density of fish >99mm at fisheries monitoring sites 2015.

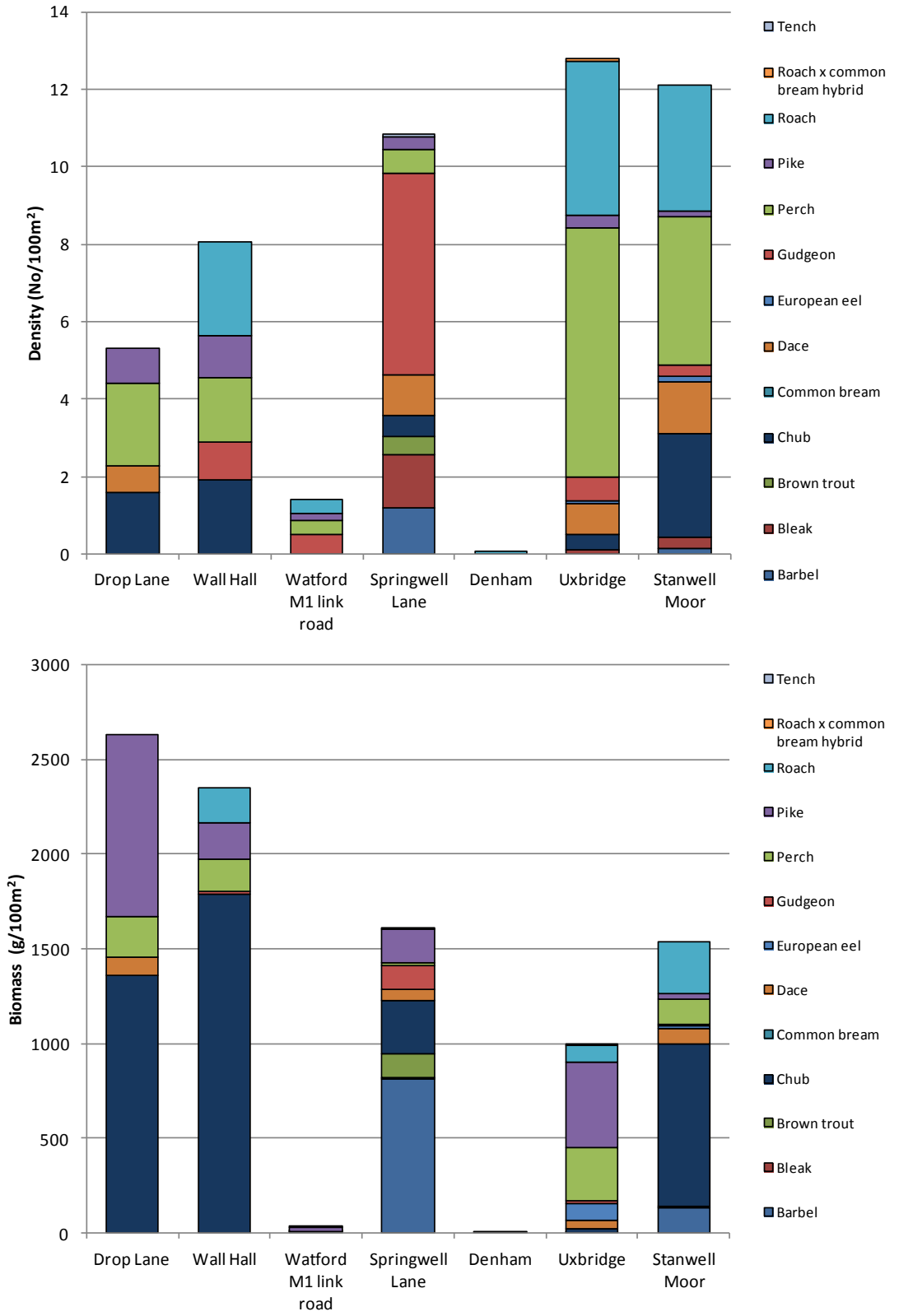

Figure 3.3: Carle and Strub estimates of fish species >99mm density and biomass at River Colne NFMP sites 2015.

The River Colne is designated as a Principal Reference Coarse fishery and is surveyed annually. Fish population surveys for NFMP purposes were conducted between May and July 2015. Over the course of 7 NFMP surveys a total of 606 fish were captured comprising 11 major species. In addition the minor species bullhead, Stone loach and minnow were also recorded during the course of surveys.

In 2015 perch were estimated to be the most abundant fish species >99mm within the River Colne with an estimated reach mean density of 2.2 ind/100m^2. Chub were the dominant species within the River Colne in terms of biomass with a reach mean of 617 g/100m^2.

River conditions at the time of surveying in 2015 contrasted with those on the Colne in 2014. Calmer weather experienced over the preceding winter and in to spring meant that river levels were far lower.

Drop Lane is the furthest upstream of our NFMP sites, and is situated immediately below the River Ver's confluence with the Colne. Flowing through a backdrop of arable farm land, the channel itself is for the most part overly deep, resulting in uncharacteristically slow flowing water for this point in the catchment. The channel is bordered by trees throughout much of its length and this shading inhibits macrophytic growth. Marginal habitat is provided by emergent beds of *Glyceria*, cover beneath undercut banks and low lying tree branches. The site produced the highest estimated biomass of fish of any surveyed in 2015. This site is surveyed triennially, with results suggesting biomass has more than tripled since last surveyed in 2012. The majority of this is attributable to the presence of large chub and pike within the catch. Good dace also featured, measuring up to 242mm in length.

Figure 3.4: Large chub captured at Wall Hall 2015 (left), and area of in-stream cover at upstream extent of site (right).

At **Wall Hall** large chub consistently feature in our surveys. Of the twenty chub captured in 2015 nine were in excess of 400mm in length, of these six were over 450mm up to 492mm. These large fish congregate beneath the overhanging willows at the upstream and downstream extents of our site, the trailing branches of which provide them with areas of dense cover. Through the middle section of our site available habitat differs with the river channel narrowed by thick mid-channel beds of club rush *schoenoplectus spp*. This results in increased velocity of water and clean gravels within areas of narrowed river channel,

providing potential spawning substrate for rheophilic fish species. Roach are consistently the species found in the highest densities at the site, with the dense macrophyte beds providing both spawning substrate and areas of shallow slack water within their stands that may be utilised by juveniles.

Heading down stream our next survey site at **Watford M1 Link Road** is situated on the Eastern edge of Watford. This survey was conducted in early July, in the immediate aftermath of a significant fish mortality that afflicted this part of the Colne. Historically this site has produced some of the highest densities of fish of any of our NFMP sites on the Colne, and was especially prolific for roach and chub. Results (Figure 3.5) from the survey illustrate the extent of the impact on this section of river. The remaining fish captured were largely juvenile fish which may be more tolerant to low dissolved oxygen levels, or been able to find refuge within areas of marginal water and avoided the passing slug of oxygen depleted water.

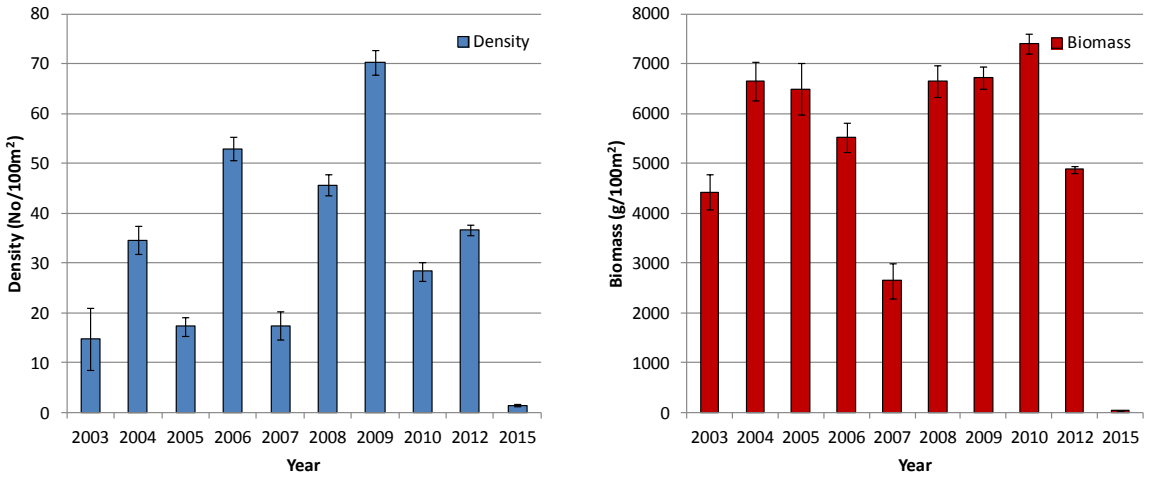

Figure 3.5: Carle and Strub density and biomass estimates (+/- 95% Confidence Limits) for fish >99mm at Watford M1 link Road 2003 – 2015.

Further downstream species diversity increases. At **Springwell Lane** the location of the site, situated approximately 300m above the confluence of the Colne with the Grand Union Canal, coupled with heterogeneity of river channel morphology and instream habitat helps the site to sustain a variety of species. Shallow glides and riffles sporadically vegetated by macrophytes such as water crows foot *ranunculus sp*. provide habitat well suited to dace, and increasingly in recent years, juvenile barbel. Areas of deeper pool habitat are also to be found and give depth of water sought by larger chub and barbel.

Barbel in particular were significant contributors to estimated fish >99mm biomass at the site, accounting for just over 50% of the total. This was in no small part due to the capture of two particulalry large barbel, which at 765mm and 722mm are the largest and third largest barbel ever captured by the Environment Agency during any survey of the River Colne. Ageing analysis of scale samples suggests these fish to be 18+ and 14+ years of age respectively. Density was still low at the site in comparison to previous years when large numbers of shoaling silver fish such as bleak and roach have been captured. These species

are likely to migrate freely between our survey site and the GUC, and so are easily missed in some survey years. As in 2014 gudgeon were estimated to be the most abundant species at the site.

Figure 3.6: Two large barbel captured during the 2015 survey of the River Colne at Springwell Lane.

Our site at **Denham** is situated adjacent to Broadwater Lake. The 2015 survey produced the lowest fish density and biomass of any of the sites surveyed this year. Temporal data suggests the fish population to be limited at the site, with density and biomass low in most survey years. However, 2015 was exceptionally low with a solitary roach captured. The site was not impacted by the pollution event that affected the Colne below Watford, and the hydrological regime seems well suited to a variety of fish species. Habitat present suggests the site should have the capacity to support a healthy fish population. Areas of clean gravels, runs and deeper glides, instream macrophyte growth and cover provided by abundant riparian vegetation and over hanging trees provide an array of micro-habitats. What pressure is affecting fish populations through this part of the Colne is unclear.

At **Uxbridge** density of fish species >99mm was the highest of any of the NFMP sites surveyed on the Colne in 2015. The site is surrounded by urban land; industrial units to the true right and a road to the left. The Colne is wide, relatively shallow with reasonable flow at this point and the open nature of the site, with little shading from trees, has enabled dense submerged macrophyte beds to become established amongst a predominantly gravel substrate. The downstream extent offers more shading from trees, although in 2015 the length of our survey site was reduced by approximately 10m at this point due to a fallen tree. The site appears to provide habitat more suited to the early life stages of many of the species present. The mean size of chub, roach and perch captured was below 130mm, with the only species captured in excess of 200mm being piscivorous fish; pike, eel and perch for which the abundance of juveniles provides ready prey. It is likely that larger adults of these species seek out areas offering greater depth of water and cover outside of our survey site, especially during daylight hours. Perch were estimated to be the most abundant species accounting for 50% of fish >99mm, whilst the capture of several relatively large pike ensured the species contributed the greatest amount to overall biomass.

The furthest downstream of our survey sites on the Colne, is located at **Stanwell Moor**. In 2014 density of fish was the lowest at the site since surveys began in 2003 at just 2.5 ind./100m^2. The 2015 results suggest fish density had increased markedly, with density of fish second only to that recorded at Uxbridge at 12.1 ind./100m^2. This section of the Colne has a reputation for holding large barbel and chub. Preferential habitat for these specimens is likely to lie outside of our survey site, barbel do feature intermittently in our catch with a single fish of 444mm captured in 2015.

In most years roach are the most abundant species at Stanwell Moor. However, in 2015 perch were the dominant species, accounting for 32% of estimated fish >99mm density, followed by roach 27%, and chub 22%. Chub were the highest contributing species to estimated biomass accounting for 56% of the total, followed by roach 18% and barbel 9%.

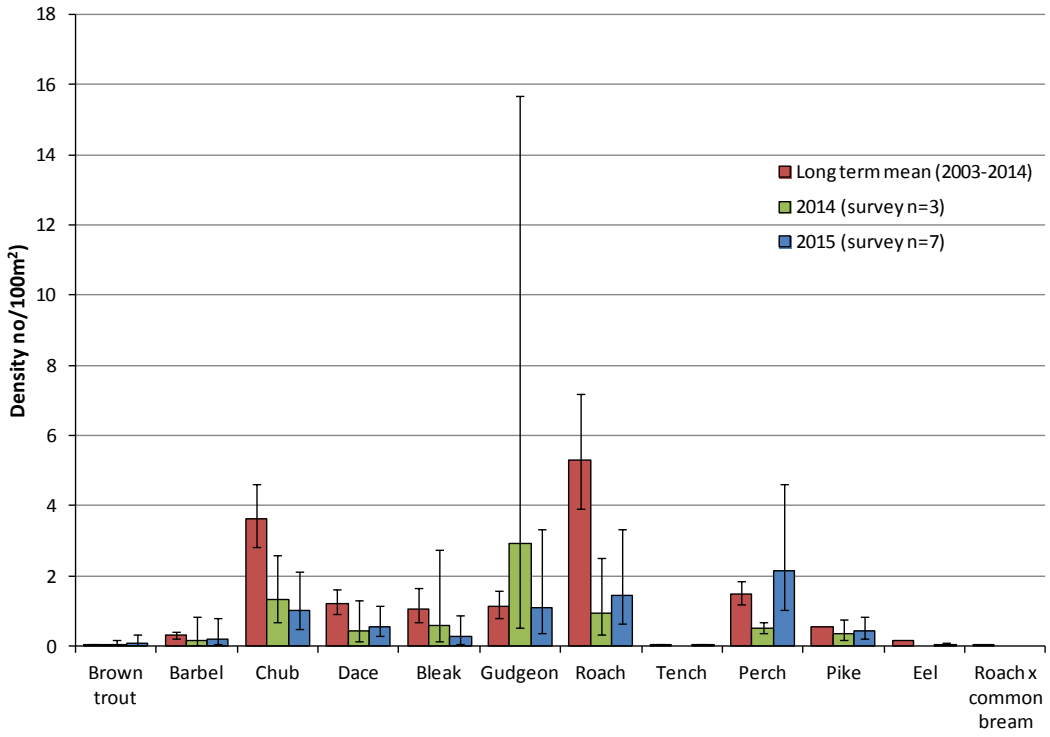

Figure 3.7: Carle and Strub mean density estimates (no/100m^2) +/- 95% Confidence Intervals for fish species >99mm captured during the 2015 River Colne survey, with comparative densities from 2014 and the long term mean.

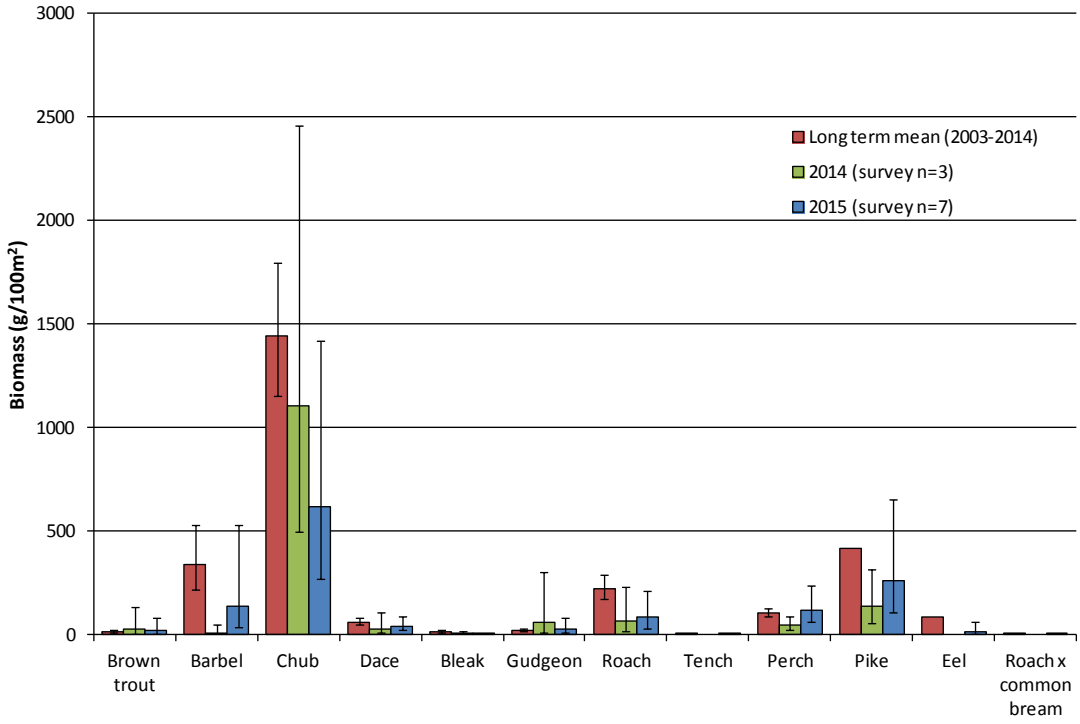

Figure 3.8: Carle and Strub mean biomass estimates (g/100m^2) +/- 95% Confidence Intervals for fish species >99mm captured during the 2015 River Colne survey, showing comparative biomass from 2014 and the long term mean.

Figures 3.7 and 3.8 detail mean estimated density and biomass of fish species captured during the 2015 survey of the River Colne, with comparative 2014 and long term mean results.

Results suggest that perch were the most abundant species >99mm within the River Colne in 2015, contributing 30% of the total estimated density of fish species, and was above the long term mean (2003 – 2014). However perch were the exception, with density estimates for all other major fish species below long term mean estimates. Roach, which in most years are the most abundant species, have slightly increased in abundance in comparison with the 2014 survey, though their density was estimated to be just 27% of the long term mean.

Chub consistently contribute the largest proportion to overall fish >99mm biomass within the River Colne. In 2015 it is estimated that despite their biomass being 57% below the long term mean for the species, they still accounted for 47% of total fish biomass.

As with density mean biomass for the majority of species in 2015, although increasing on 2014 estimates, are below the long term mean. The exceptions to this are perch, gudgeon and brown trout.

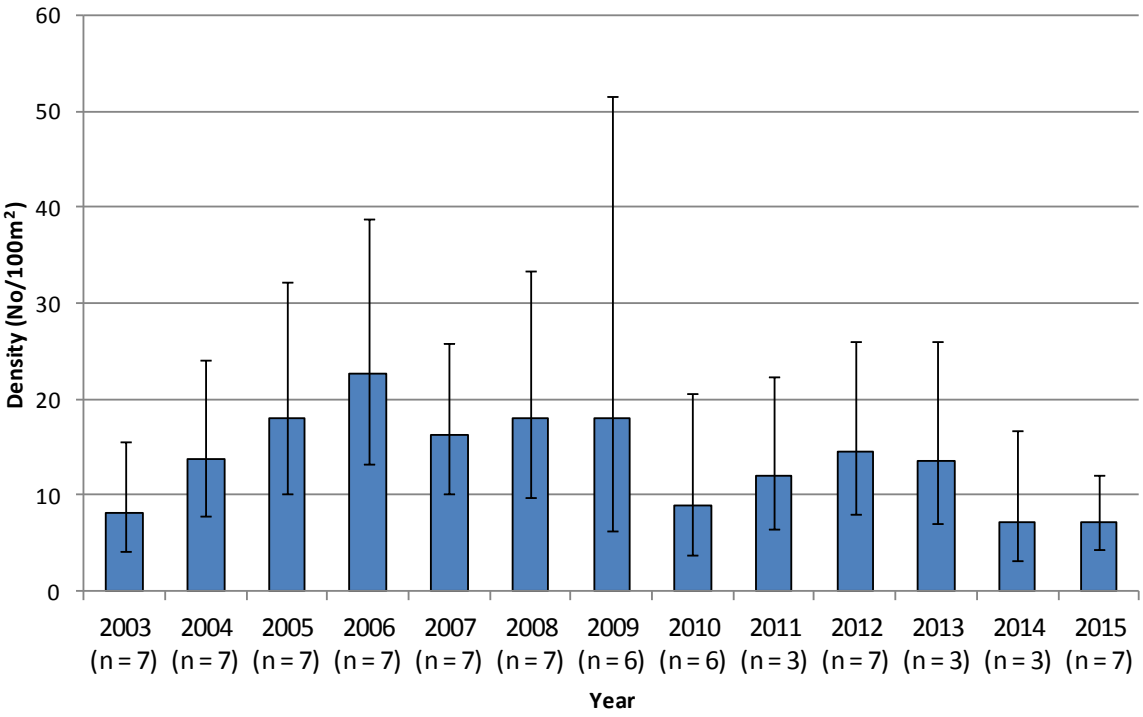

Figure 3.9: Carle and Strub estimates of density of fish species >99mm (+/- 95% Confidence Intervals) for the River Colne 2003 – 2015 based on data collected from NFMP monitoring sites. (Number of surveys in year shown in parentheses)

A temporal comparison of estimated total density of fish species >99mm (Figure 3.9) suggests that density in 2015 was the lowest since NFMP surveys of the Colne began in 2003.

The ability of fish species to attain a size at which they are more resilient to hydrological extremes can be key to the production of strong year classes. Within a normal population structure, abundance within year classes decreases with age, as a consequence of natural mortality, with younger fish contributing the majority of the population present, and successively fewer individuals with increasing age. Ageing data derived from scale samples taken during River Colne surveys suggests the most prevalent cyprinid species; roach and chub, typically attain a length in excess of 99mm within their third summer of growth, whilst juvenile dace may reach this size in their second year. As a result progeny of spawning by these species in 2012 or 2013 would start to feature in our surveys as fish >99mm in 2015, and would be expected, assuming a normal population structure, to be significant contributors to total density of fish >99mm.

The exceptionally high river discharge during winter 2013/14 (see Figure 2.3, page 10) is likely to have had some impact on the abundance of these early year classes, which are especially prone to entrainment and 'wash out'. The effects of temperature on successful recruitment may also play a part. A succession of relatively cool years (see Figure 2.2, page 9) since an exceptionally warm 2006 may have influenced developmental rates of juvenile fish. This may affect their resilience to high flows, increase their risk of predation, and subsequently play a part in shaping the overall density of fish>99mm.

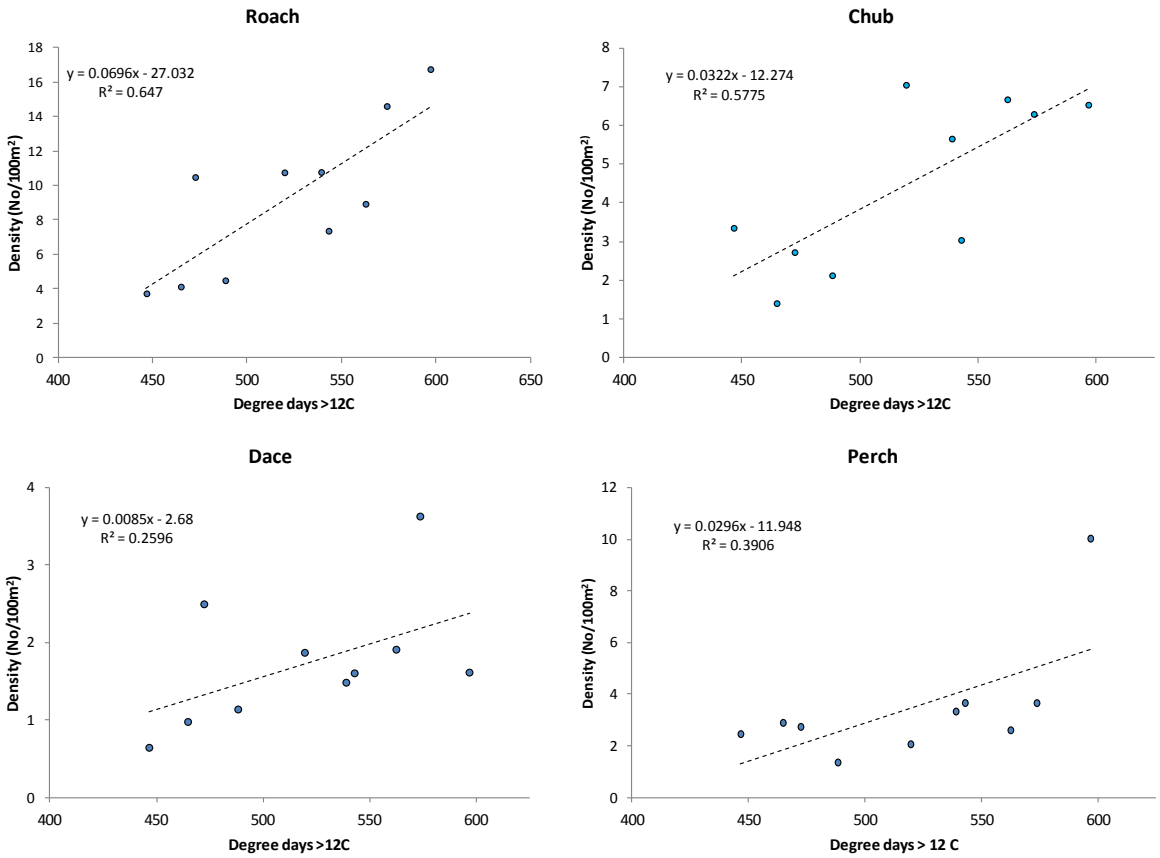

Figure 3.10: Scatter plots of annual estimated mean densities of fish species against degree days > 12^{o}C (three year moving average) with fitted linear trend lines for the River Colne 2003 – 2015. Temperature data from the Met Office Hadley Central England Data Centre 2015. (N.B. Scale on Y axis varies)

Figure 3.10 shows estimated annual mean density of the four most abundant species within the Colne plotted against the three year mean for degree days above 12^{0}C.
The R^2 coefficient correlation statistic gives an indication of the goodness of fit, or degree to which density and three year mean for degree days >12^{0}C correlate for each species, with values closer to 1 indicative of stronger relationships. Although this representation is not statistically significant, there is some evidence to suggest that density of some species is influenced by temperature. Densities of roach and chub appear to be the most closely correlated to the three year mean for degree days >12^{0}C.

Ultimately, levels of recruitment are likely to be significantly shaped by a complex interplay of hydro-climatic conditions, with years in which flow and temperature are favourable for juvenile survival and growth producing the strongest year classes. The highest estimated density of fish >99mm occurred in 2006. Although this year itself was exceptionally warm, when looking at densities >99mm the formative driver for increased densities of fish >99mm is likely to be a succession of relatively warm years and benign winter and summer flows on the Colne between 2003 and 2006, facilitating increased survival of fish beyond this size threshold.

Water Framework Directive survey results 2015

Site	3-spined stickleback	Pike	Bullhead
Colney Heath	4	1	7

Table 2: Number of each species captured in a single electric fishing run at Colney Heath Water Framework Directive monitoring site 2015

Our site at **Colney Heath** is situated on the upper reaches of the River Colne approximately 150m downstream of the road bridge that crosses the river on Coursers Road. Data from the survey is used to classify the waterbody Colne (upper east arm including Mimshall Brook). As the name suggests land surrounding the river channel is predominantly heath land. For the most part the river channel is over wide and un-naturally straight. Some localised heterogeneity of channel morphology is evident, with isolated gravel berms and scouring on bends providing small pockets of deeper water.

Figure 3.11: Bullhead (left) from Colney Heath, and habitat present at the site (right).

The hydrological regime in this part of the Colne is likely to be one of the key factors limiting fish populations. Upstream, the main tributary converging with the Colne is the Mimshall Brook, flows of which are augmented by the convergence of the Catherine Bourne and Potters Bar Brook. Significant channel modification of these tributaries, with extensive straightening and over widening of the channel, severely impacts flows at Colney Heath. In 2012 the fish population survey scheduled for that year was cancelled due to the river running dry. Conversely, in response to high rainfall accelerated conveyance of water from the channelized tributaries results in the onset of rapid flood events and high peak discharges. These factors make it extremely difficult for fish populations to persist within this part of the Colne. Results from the 2015 survey are similar to those of the 2013 survey, and suggest the site will be classified as 'Bad' for fish under the Water Framework Directive.

Merchant Taylors investigation

In early July 2015 approximately 5 miles of the River Colne between Watford and its convergence with the Grand Union Canal to the East of Rickmansworth, was affected by a significant fish mortality. In response to this the Environment Agency conducted a fish population survey of the River Colne as it flows through the grounds of Merchant Taylors School, Northwood, in order to ascertain the extent of the impact upon resident fish populations. This site, although not part of our routine monitoring programme, had been surveyed on three occasions prior to the mortality within the past decade, and so provides valuable base line data against which the results of the 2015 survey may be compared. In addition a timed Catch Per Unit Effort (CPUE) survey of approximately 500m of the river upstream of our historical site was conducted.

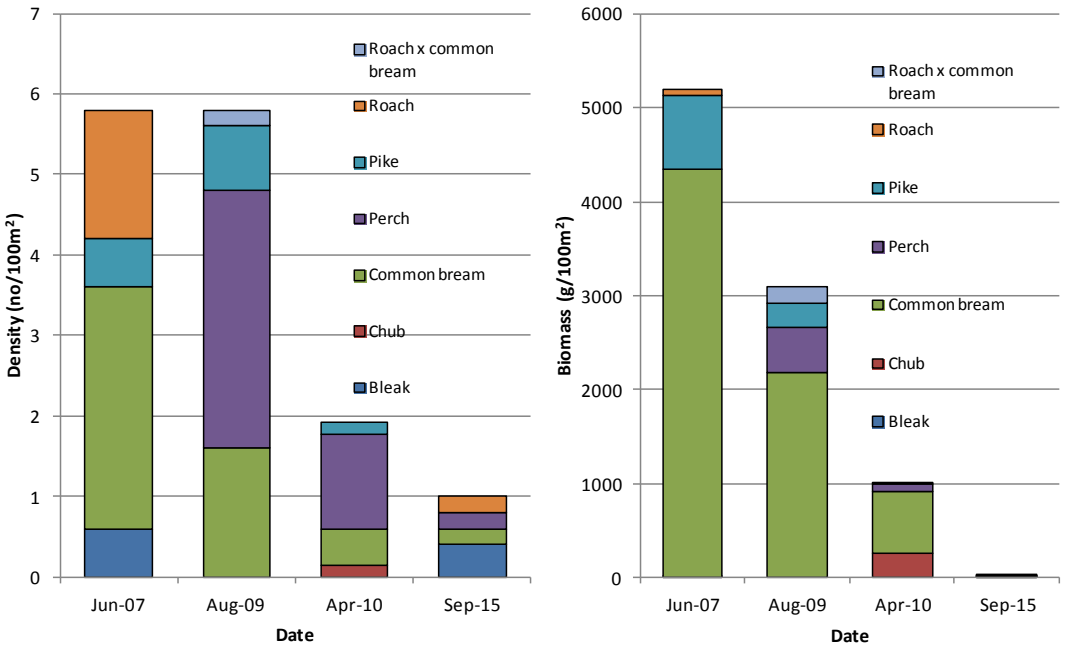

Figure 3.12: Carle and Strub estimates of density and biomass of fish species >99mm at Merchant Taylors 2007 – 2015

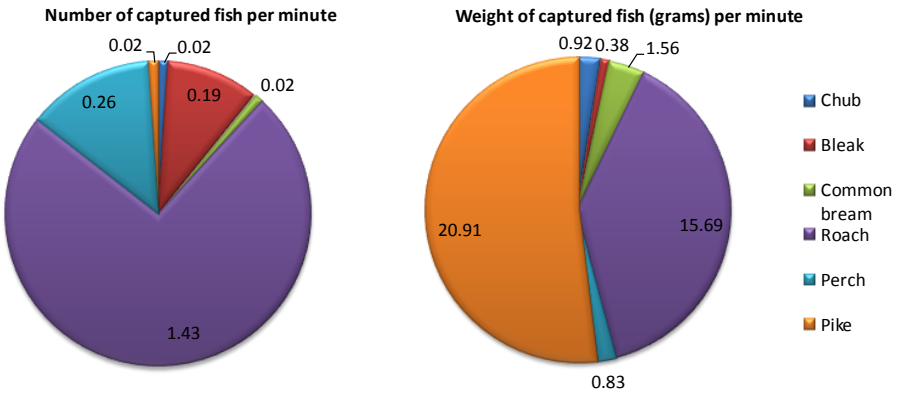

Figure 3.13: Catch Per Unit Effort results showing number and weight(g) of fish species captured per minute on the River Colne at Merchant Taylors

Quantitative estimates for fish >99mm at the site surveyed in previous years suggest that both density and biomass were lower in 2015 than in any previous survey. In total 23 fish were captured with only 5 of these being >99mm. The extremely low biomass estimate is indicative of the fact that the catch was comprised of small fish, with the largest individual being a common bream of 136mm.

The CPUE survey encompassed a larger area of river, and similarly to the quantitative site produced low numbers of small fish, with 82 fish captured, only 21 of which were >99mm. Roach were the most abundant species with 60 captured up to 137mm in length. Pike dominated biomass, with only one pike of 484mm being caught. Eleven perch up to 74mm, one common bream of 161mm, one chub of 145mm, and eight bleak up to 120mm completed the catch.

The fish mortality affecting this part of the Colne was in response to extremely low dissolved oxygen levels, precipitated by thunderstorms and heavy rainfall following a prolonged period of warm weather. Smaller fish may be more resilient to low dissolved oxygen levels, possessing a lower metabolic demand for oxygen than larger fish, whilst also being more likely to be able to find refuge in marginal pockets of oxygenated water. Within this section of the Colne a backwater constructed in 2007 by the Environment Agency, working closely with Carpenders Park Angling Club, is likely to have remained unaffected by the passing slug of deoxygenated water, and may have offered sanctuary for fish during the event. A further survey of the site is scheduled to be completed in 2016 to gauge ongoing recovery of fish stocks.

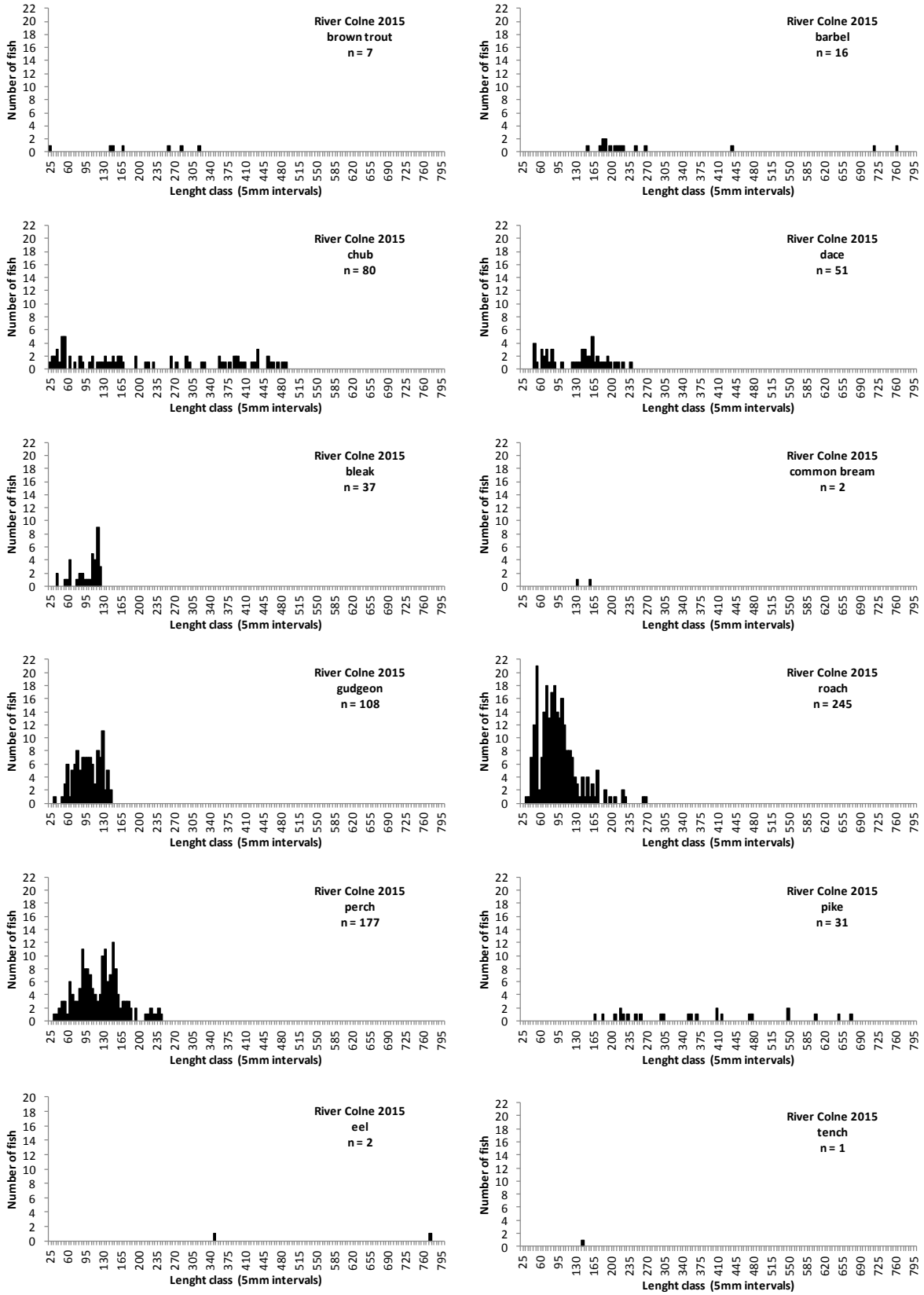

Figure 3.14: Length frequency histograms for fish species captured during the 2015 survey of the River Colne

Colnebrook and Wraysbury River

In its lower reaches two major distributaries of the River Colne diverge to the west of the main river channel. The Colnebrook diverges from the River Colne at Uxbridge Moor before flowing south for some 18km to its confluence with the River Thames near Hythe End, whilst the Wraysbruy River leaves the Colne at West Drayton before rejoining some 9km downstream. Two sites were surveyed on the Colnebrook, and one on the Wraysbury River in 2015 for dual NFMP and WFD purposes.

Figure 4.1: Lower River Colne catchment showing location of fisheries monitoring sites on the Colnebrook and Wraysbury River 2015 and comparative estimated density of fish >99mm

Colnebrook

National Fisheries Monitoring Programme results 2015

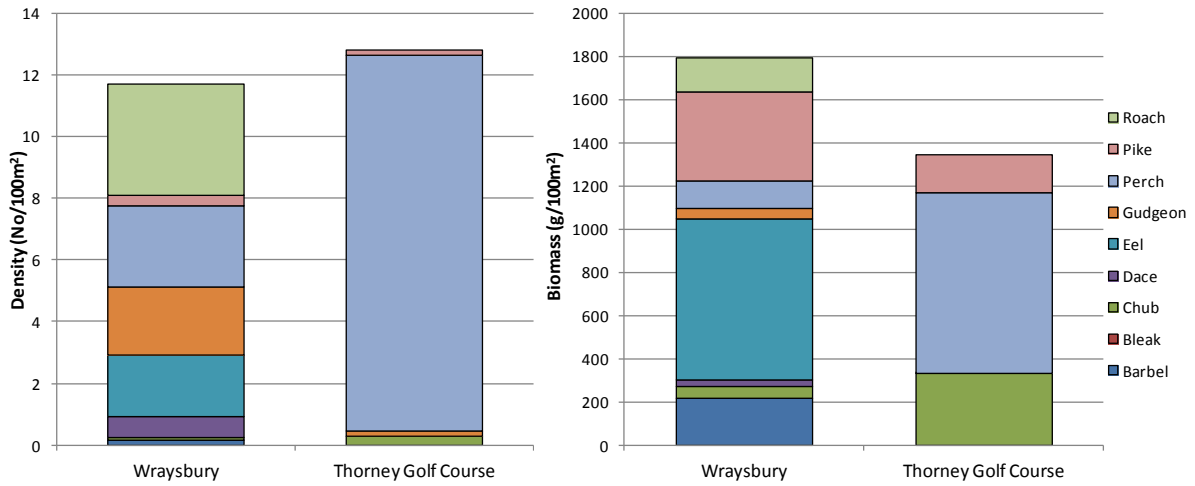

Figure 4.2: Carle and Strub density and biomass estimates for fish species >99mm at sites on the Colne brook 2015

Our surveys of the Colnebrook were conducted during June 2015. The site at **Wraysbury** was chosen as a replacement for our site at Hythe End, which had previously been surveyed annually. The nature of the Hythe End site, being deep and wide, consistently led to questionable capture efficiency making it difficult to obtain accurate population estimates, and it was clear that we were not gaining a true representation of the fish community within this part of the Colnebrook. The site at Wraysbury encompasses habitat more in keeping with this section of the Colnebrook, with shallow runs and glides over submerged and emergent macrophyte beds and clean gravels. Marginal habitat is provided by lush riparian vegetation, and overhanging trees which provide areas of shade, cover and slacker water creating marginal areas of silt deposition.

Results of the 2015 survey suggest that fish are more abundant and the population more diverse within this part of the Colnebrook than our previous surveys of Hythe End revealed. In particular eel abundance at Wraysbury was found to be much higher. The species can be difficult to sample effectively from deep water courses, particularly those which require the use of a boat in order to survey, as was the case at Hythe End, and the ability to sample the whole of the Wraysbury site by wading has undoubtedly helped to gain a more accurate picture of their true abundance. Roach were the most abundant species at Wraysbury accounting for 30% of fish >99mm density, it was apparent that no one species was dominant at the site, with perch, eel and gudgeon being present in similar densities. Barbel also featured in the catch. One adult and a single juvenile of the species were captured indicating that successful spawning of the species is occurring in the vicinity of the site

Thorney Golf Course is surveyed triennially. Although the site possesses varied hydro-morphology and habitat, the fish community it supports is not as diverse. The site supports a healthy population of perch which account for 95% of the estimated density of fish species >99mm, and were also the highest contributing species to biomass at the site, with chub and pike also accounting for a significant proportion.

Figure 4.3: Colnebrook at Thorney Golf Course (top left) and Wraysbury (top right) and barbel captured during the 2015 survey of Wraysbury (bottom).

Water Framework Directive survey results 2015

Waterbody	Fish	Invertebrates	Macrophytes and phytobenthos	Ammonia	Dissolved Oxygen	Phosphate
Colnebrook	Bad	Not yet assessed	Not yet assessed	High	High	Poor

Table 3: Water Framework Directive classifications 2015 for fish and some of the key elements affecting fish populations within the Colnebrook WFD waterbody

Both sites surveyed in 2015 are also used for Water Framework Directive classification. The 2015 classification for fish is 'Bad' for the Colnebrook waterbody. This is based on monitoring data from 2014 surveys which included the now defunct Hythe End survey site. The quality of data collected from this site no doubt had a bearing on the overall status of the water body. Having replaced this site with the new site at Wraysbury it is likely that overall waterbody status will improve, due to an increase in both numbers of fish and species diversity.

Site	Barbel	Bleak	Chub	Dace	Eel	Gudgeon	Perch	Pike	Roach	Bullhead	Minnow
Wraysbury	2	1	1	9	24	9	16	5	17	10 - 99	10 - 99
Thorney Golf Course			2			1	17	1		10 - 99	

Table 4: Number of each species captured in a single electric fishing run at Colnebrook Water Framework Directive monitoring sites 2015.

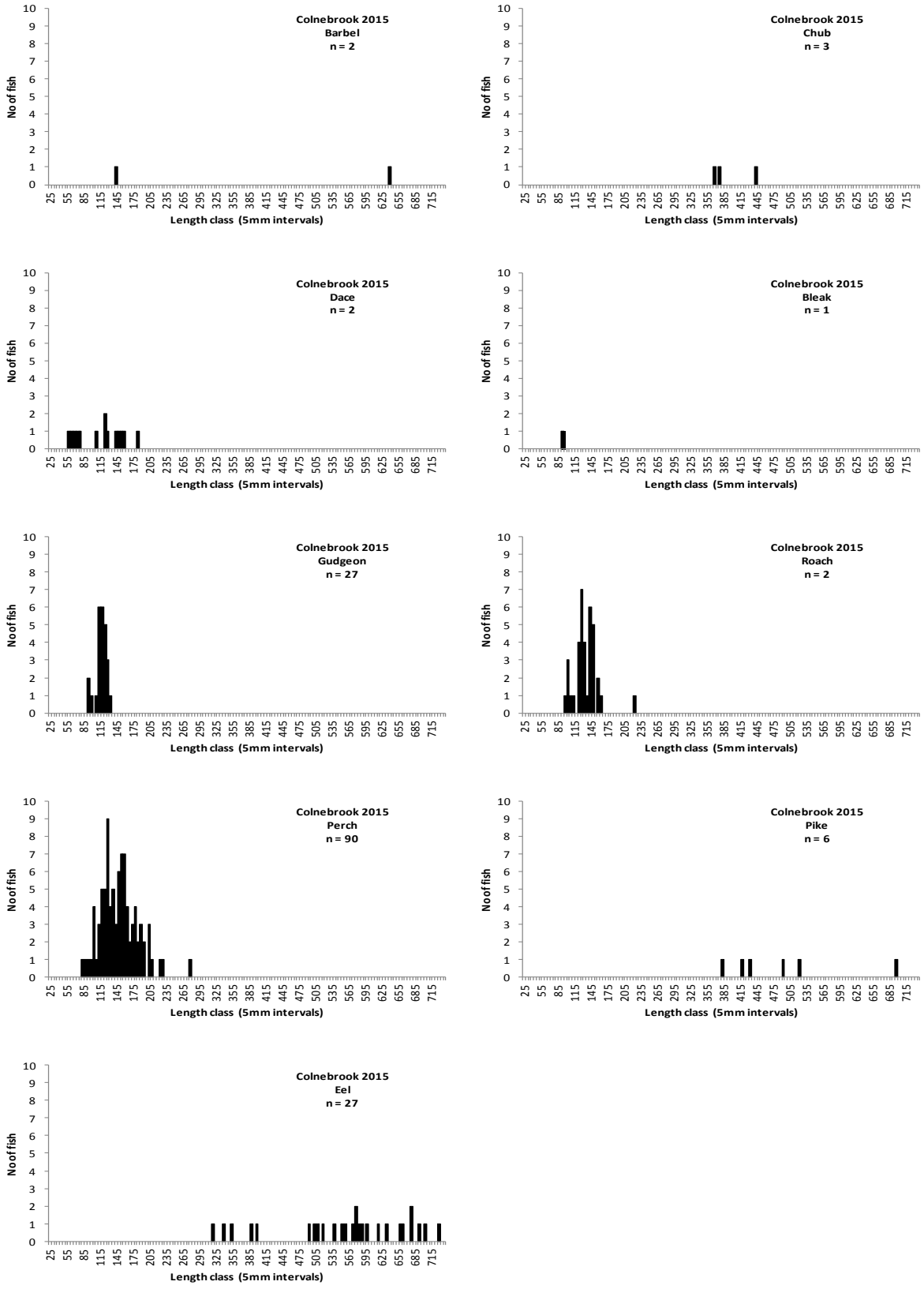

Figure 4.4: Length frequency histogram for fish species captured during 2015 surveys of the Colnebrook.

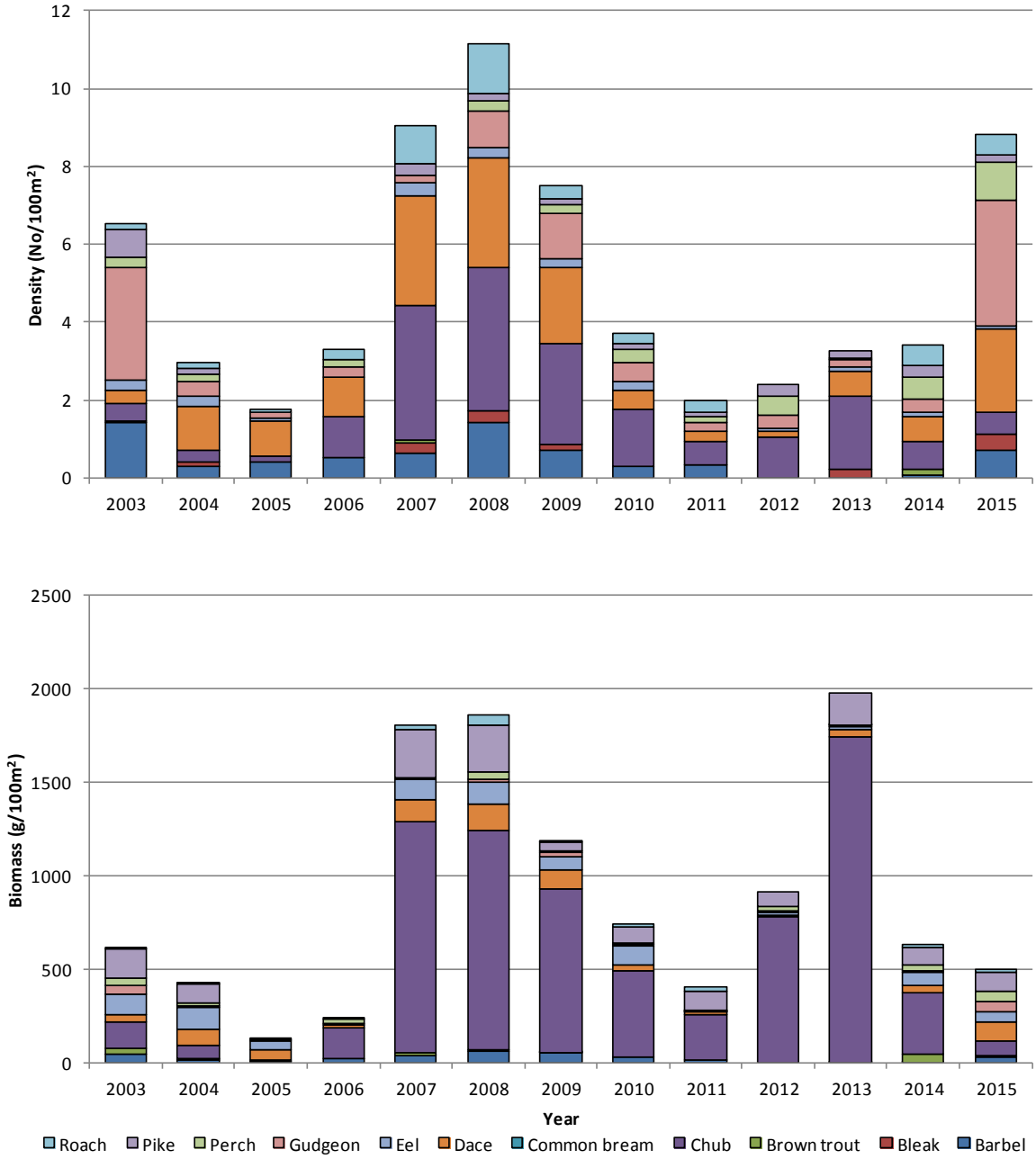

Figure 4.5: Carle and Strub density and biomass estimates for fish species >99mm at Harmondsworth Moor 2003 – 2015.

Our survey site on the Wraysbury River is situated within **Harmondsworth Moor** to the north of Heathrow airport Terminal 5. The site has been surveyed annually since 2003 providing us with a long term data set. Density and biomass have both fluctuated over the years of our surveys. Water levels were noticeably low at the time of surveying in June 2015 than in the previous few years of surveys. Despite this estimated density of fish species >99mm was the highest at the site since 2008, with nine major fish species featuring in the catch as well as the minor species minnow, stone loach and bullhead. The low biomass at the site is indicative of the fact that the majority of fish captured were either relatively small

species well suited to fast flowing shallow water, such as dace, for which the runs over gravels interspersed with water crowsfoot *ranunculus spp*. that proliferate throughout our site provide ideal habitat, or smaller juveniles of species that have the potentail to grow much larger such as chub and barbel. Gudgeon were the most abundant species >99mm, and along with the juvenile barbel were found to be utilising the cover provided by the dense submerged macrophyte beds. The young barbel captured are of a size that suggests they are likely to be the legacy of an Environment Agency stocking of 250 barbel in December 2014.

Figure 4.6: Looking towards the upstream extent of our survey site at Harmondsworth Moor.

The shallow nature of the site means that for larger fish species habitat present may only be utilised at certain times of the year. Extensive areas of well oxygenated clean gravel beds are present, which provide ideal spawning substrate for rheophilic species such as chub, barbel and dace. These species may congregate within these areas during spring and early summer in order to spawn. Dace were the highest contributing species to biomass of fish >99mm in 2015 providing 20% of the total. Biomass was particularly high in 2013 when a number of large chub were captured, these fish are likely to have sought areas of the river offering deeper water upstream of the survey site at the time of the 2015 survey.

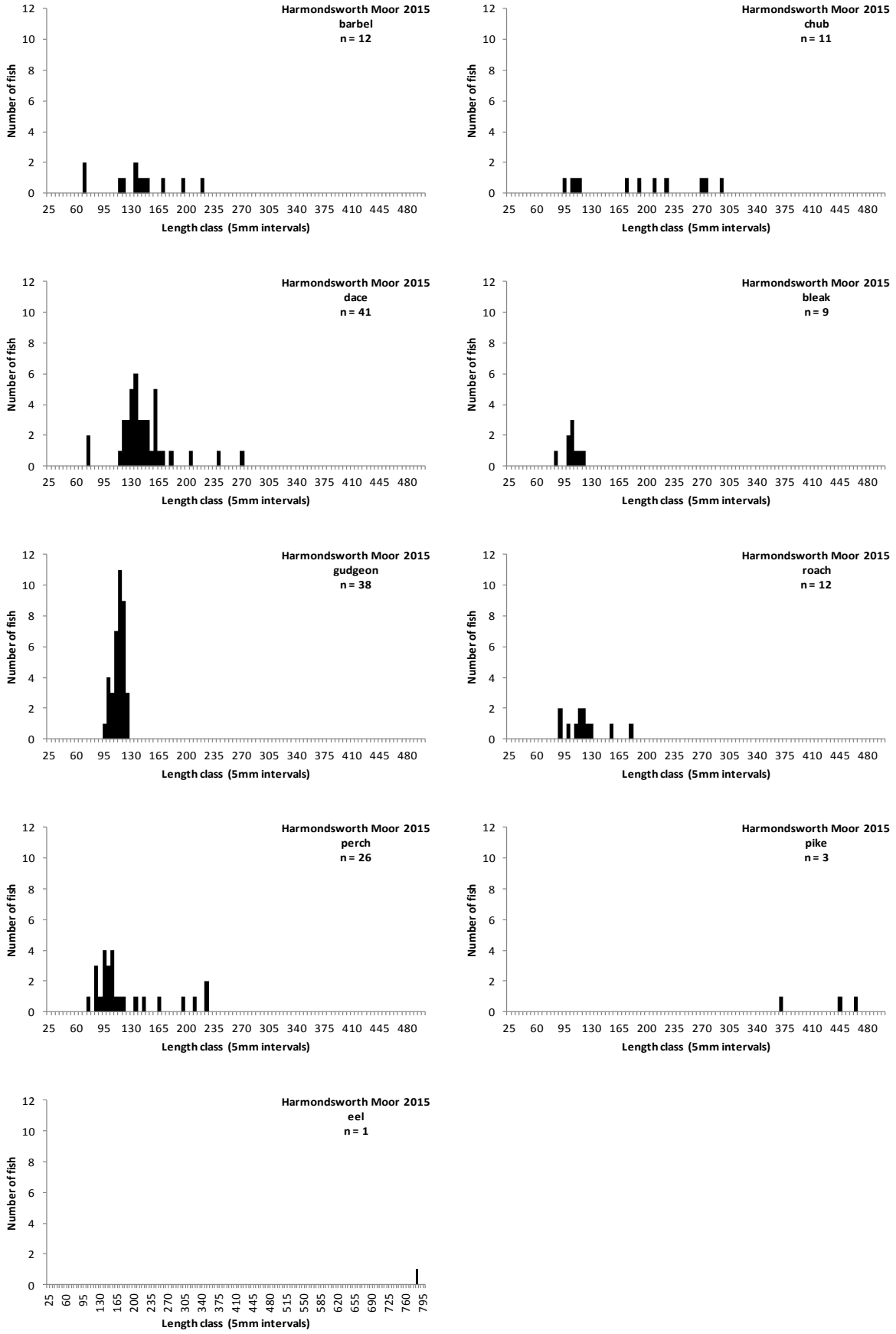

Figure 4.7: Length frequency histograms for all major fish species captured at Harmondsworth Moor 2015.

River Chess

Catchment overview

The River Chess is a chalk stream tributary of the River Colne and rises in the town of Chesham. The river runs in a south easterly direction through a rural landscape before it flows through the towns of Chorleywood and Rickmansworth where it converges with the Colne. Flow, although augmented by treated effluent from sewage treatment works, is primarily derived from groundwater, with the chalk aquifer providing cool water all year round, which in turn enables a healthy brown trout population to thrive. Two sites were surveyed in 2015 as part of our biennial Wild Brown Trout monitoring programme, the data from which is also used for WFD classification purposes.

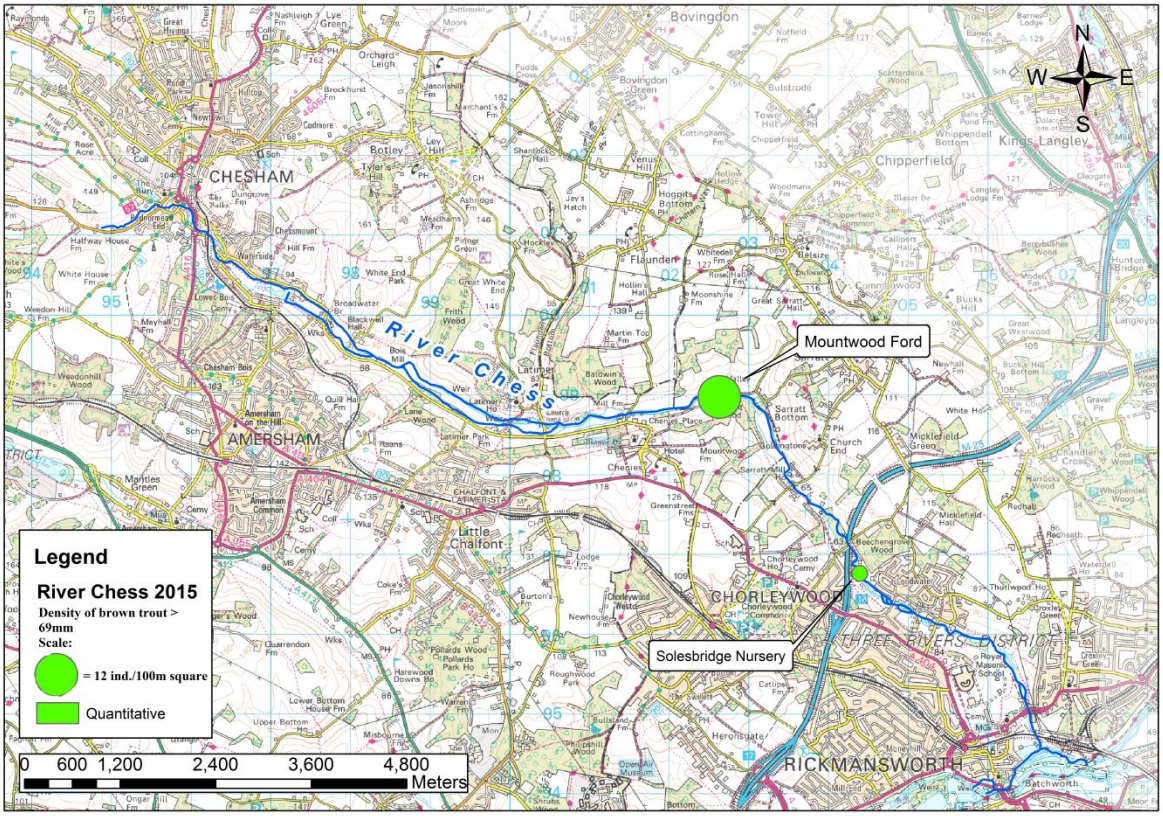

Figure 5.1: River Chess catchment showing the location of 2015 survey sites and comparative estimated density of brown trout >69mm.

Water Framework Directive classifications

Waterbody	Fish	Invertebrates	Macrophytes and phytobenthos	Ammonia	Dissolved Oxygen	Phosphate
Chess	Moderate	High	Moderate	High	High	Poor

Table 5: Water Framework Directive classifications 2015 for fish and some of the key elements affecting fish populations within the Chess WFD waterbody.

Main pressures affecting fish populations

Morphology: Within the Chess waterbody the main pressure impacting upon fish populations are barriers to migration. These are a mixture of flood defence and more commonly non- flood defence structures. The mill at Scotsbridge in the lower reaches of the Chess creates an immediate significant barrier to fish migration between the Chess and the Colne. Further mill structures at Solesbridge and Sarratt Millhouse create further potential barriers to fish migration. The many weirs found throughout the Chess range from little more than a few centimetres, to significant flood defence structures such as at Chess Falls, Loudwater. Such barriers to migration can significantly impact upon fish species at all life stages, inhibiting spawning migrations of adult fish as well as downstream drift of larval and juvenile life stages. Impoundments also affect the hydrology of river systems, slowing flow and facilitating increased deposition of fine sediments which may impact upon the viability of spawning gravels utilised by salmonids and rheophilic coarse species.

Figure 5.2: Examples of obstructions to fish passage present on the River Chess; river control structure at Sarrattmill House (left) and weir at Chess Falls (right)

Phosphate: Elevated phosphate levels within the catchment, borne out by the 'Poor' WFD classification for this element, are primarily the result of treated effluent from Chesham stw and to a lesser extent Chenies stw entering the watercourse. This impacts upon fish populations by fuelling the process of eutrophication, and ultimately altering the plant community structure from that which would naturally be found within a chalk stream environment.

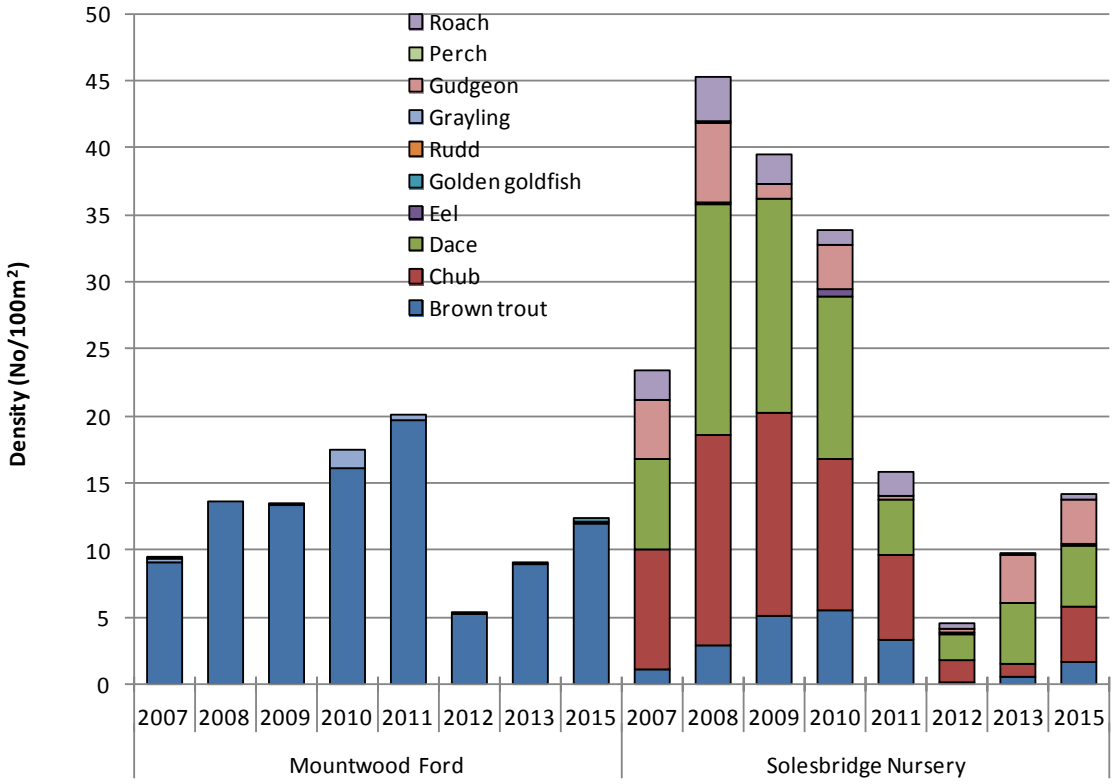

Figure 5.3: Carle and Strub density estimates for fish species >69mm at River Chess fisheries monitoring sites 2007 - 2015.

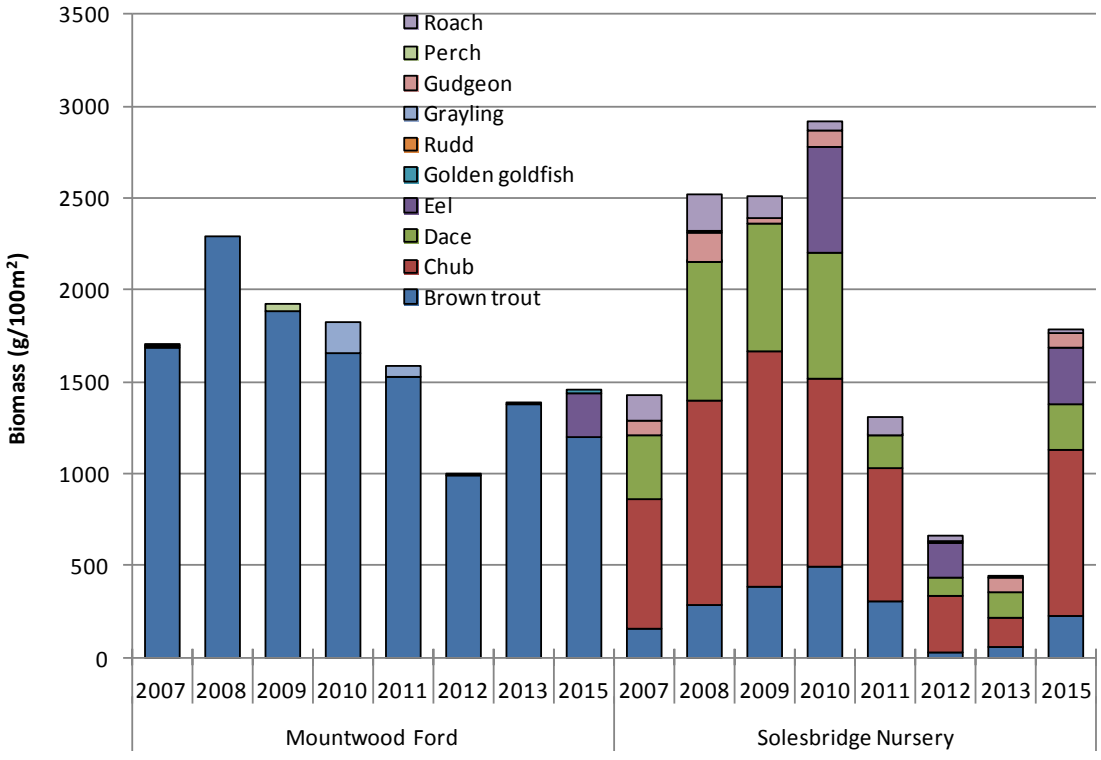

Figure 5.4: Carle and Strub biomass estimates for fish species > 69mm at River Chess fisheries monitoring sites 2007 – 2015.

Our two wild brown trout monitoring sites on the River Chess are contrasting in both available habitat and resultantly the fish populations they support.

At **Mountwood Ford** the river flows adjacent to garden lawn and watercress beds to the true left. Shading is limited with the open nature of the site meaning dense macrophyte beds have become established, and these provide the majority of available habitat for the resident fish population, as well as harbouring prey organisms. Riparian and instream vegetation are managed by both the land owner and the small syndicate that controls the fishing rights. Macrophytic growth can become excessive, elevated phosphate levels within the catchment in tandem with high light levels reaching the river channel facilitate this, and in the week prior to our survey substantial weed cutting had taken place throughout the site. Substrate throughout the site consists predominantly of gravels and sands.

Brown trout dominate estimated density and biomass of fish at Mountwood Ford, with the only other species featuring in the 2015 survey being goldfish, which are likely to be the result of a recent illegal introduction in the vicinity of the site, and a single large eel. A range of brown trout size classes are evident. The site provides good habitat for juveniles, with marginal watercress beds providing areas of cover and slacker flow, with submerged macrophyte beds, overhanging trees and riparian vegetation as well as deeper depressions in the river bed providing habitat sought by larger individuals. Of 94 brown trout captured during the 2015 survey 61% were below 150mm in length, suggesting that good natural recruitment is occurring within this part of the Chess.

The site at **Solesbridge Nursery** is situated approximately 3km downstream. Here the river is bordered by deciduous trees, the shade of which inhibits any significant macrophyte growth. Velocity of water is not as great as at Mountwood Ford with substrate primarily sands and silt, with localised pockets of clean gravel. Over the years the fish population sampled at this point has typically been more diverse with brown trout less abundant. Coarse fish species accounted for 88% of the estimated density of fish in 2015. Dace are the most abundant species, followed by chub and then gudgeon. Eel and roach also feature in the catch.

Temporal fluctuation in the mean estimated density of brown trout >69mm for the River Chess based on our surveys of Mountwood Ford and Solesbridge Nursery is shown in Figure 5.5. Three year moving averages for mean summer and winter flow over the same time period are also plotted. Whilst density dependent mechanisms are known to naturally regulate brown trout abundance through competitive interactions for resources, it is also recognised that successful recruitment within brown trout populations can to some extent be mediated by flow (Milner *et al*, 2003). Winter flows can be of particular importance to the success of brown trout spawning which takes place during the autumn and winter months. Low winter flows may reduce wash out of fine sediments within spawning gravels affecting their viability, and also the ability of brown trout to traverse the river system in order to reach spawning grounds. Low water levels also reduce the size of available areas of viable spawning gravels. Low summer flows may impact upon juvenile survival due to a reduction in depth of water and access to preferential marginal stream habitat, as well as increasing potential predation upon them (Riley *et al*, 2009).

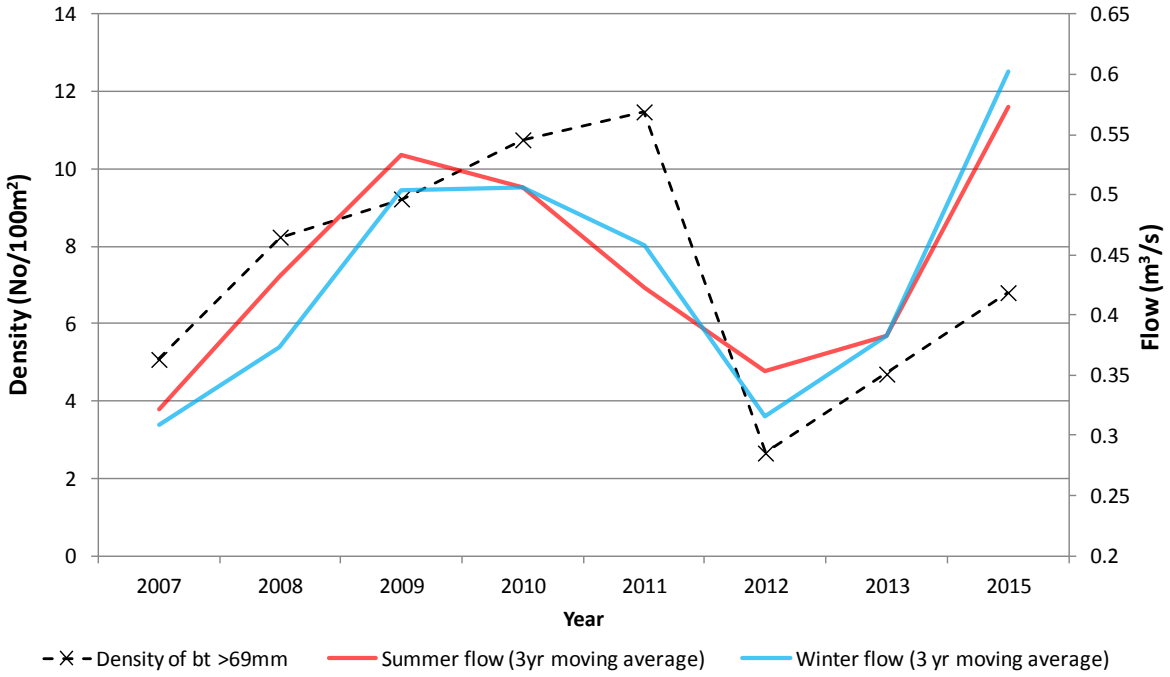

Figure 5.5: Estimated mean density of brown trout >69mm in the River Chess (Mountwood Ford and Solesbridge Nursery combined) 2007 – 2015, showing 3 year moving averages for mean summer (April – September) and winter (October of previous year to March of year) flow. Flow data from the Environment Agency Rickmansworth gauging station.

Figure 5.5 suggests some evidence for patterns of brown trout abundance closely following those of both summer and winter flow within the River Chess. Three year moving averages for summer and winter flow are used and are indicative of the cumulative effects of flow in consecutive years on trout >69mm abundance, which will be comprised of fish from multiple year classes. The lowest density of brown trout was recorded in 2012 and coincides with particularly low flows on the Chess throughout the summer and preceding winter of 2012.

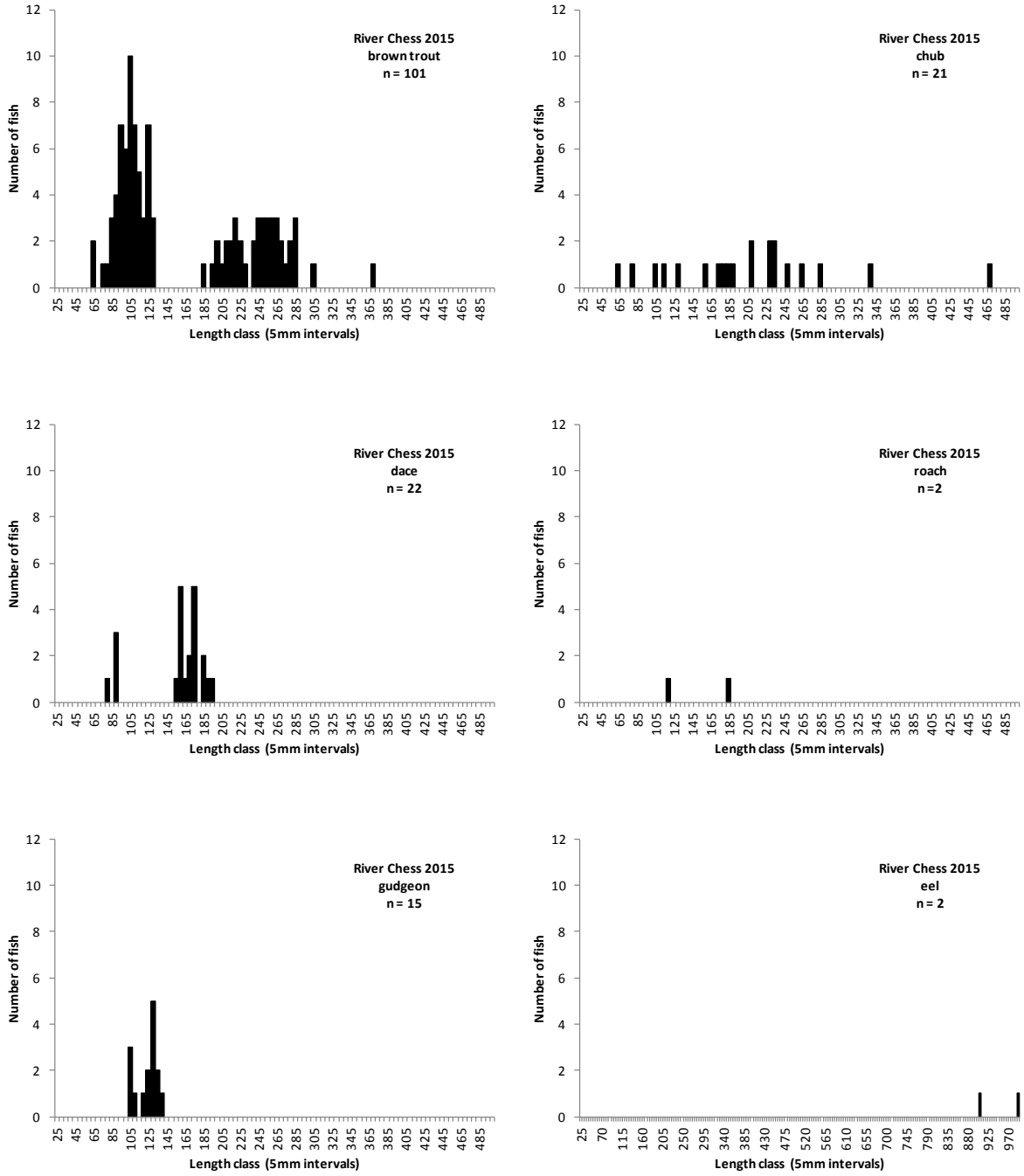

Figure 5.6: Length frequency histograms for fish species captured during the 2015 survey of the River Chess.

River Bulbourne

Catchment overview

The River Bulbourne is a tributary of the River Gade. Rising from springs at Dudswell the river flows approximately 11km south easterly through the conurbation of Berkhamsted and on to join the River Gade to the south of Hemel Hempstead. The Grand Union Canal runs parallel to the Bulbourne along its entire length. Two investigative surveys were carried out on the Bulbourne as it flows through Boxmoor in late April 2015. Their purpose was to ascertain the status of the fish population in advance of planned river habitat enhancement works the Environment Agency in partnership with the Boxmoor Trust are looking to implement.

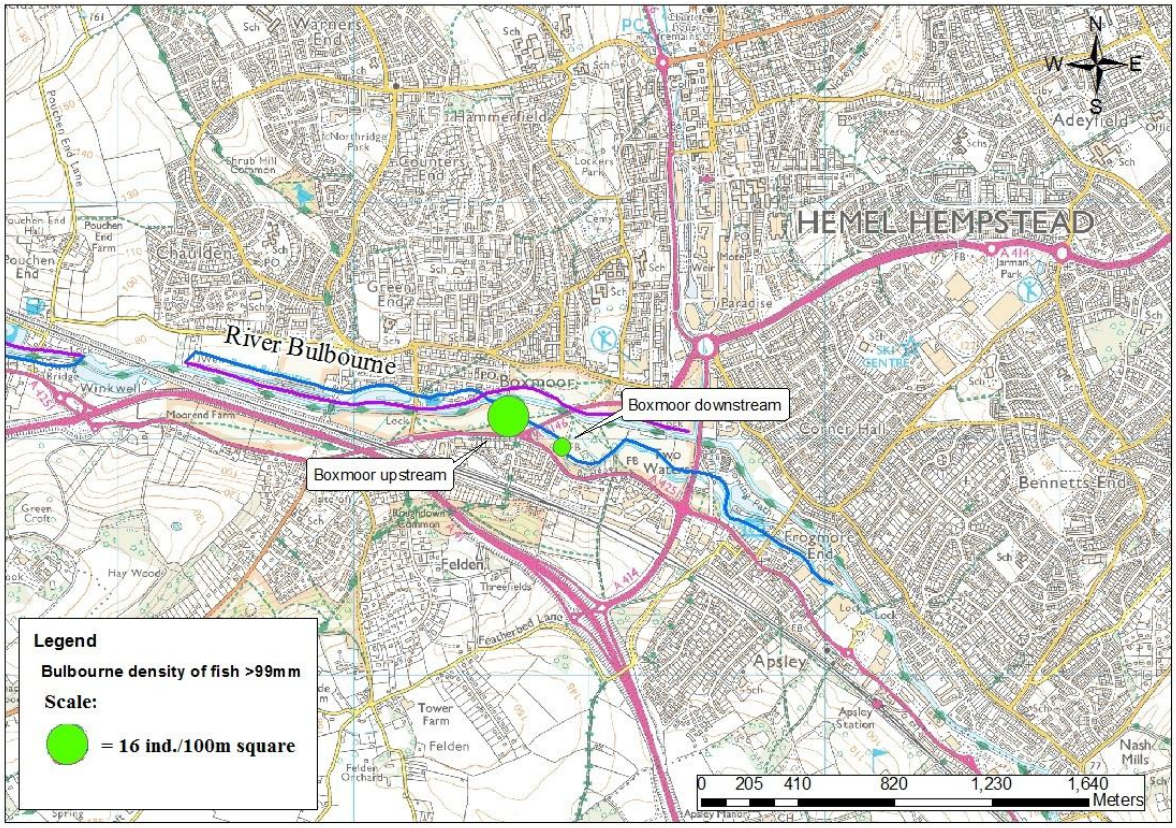

Figure 6.1: Location of River Bulbourne fisheries survey sites 2015 showing comparative densities of fish >99mm

The two sites were selected due to the contrasting habitat found within each. The quality of habitat available to fish populations within the upstream site is poor. Anthropogenic alterations have left river morphology highly degraded, with channelization throughout creating a uniformly straight, over wide river channel. Hydrology in turn is highly un-natural with little flow, resulting in increased deposition of fine sediments over much of the gravel substrate. Bar a footbridge the site is completely un-shaded. Bare grass banks border the entirety of the site with significant riparian vegetation absent. Despite the open nature of the site instream macrophytic growth is also limited.

The second site is situated approximately 150m downstream. Despite its close proximity habitat here exhibits far greater diversity. Narrower, with greater sinuosity the river possesses greater hydrological heterogeneity with shallower gravel riffles and deeper runs present. Cover for fish species is provided by increased instream and riparian vegetation, woody debris and over hanging trees. This site was chosen as it was thought to closer resemble habitat that may naturally be found within the Bulbourne.

Figure 6.2: Fish surveys in progress at Boxmoor upstream site (top left), Boxmoor downstream site (top right), large adult roach captured from Boxmoor upstream site (bottom left) and dace from Boxmoor upstream site (bottom right).

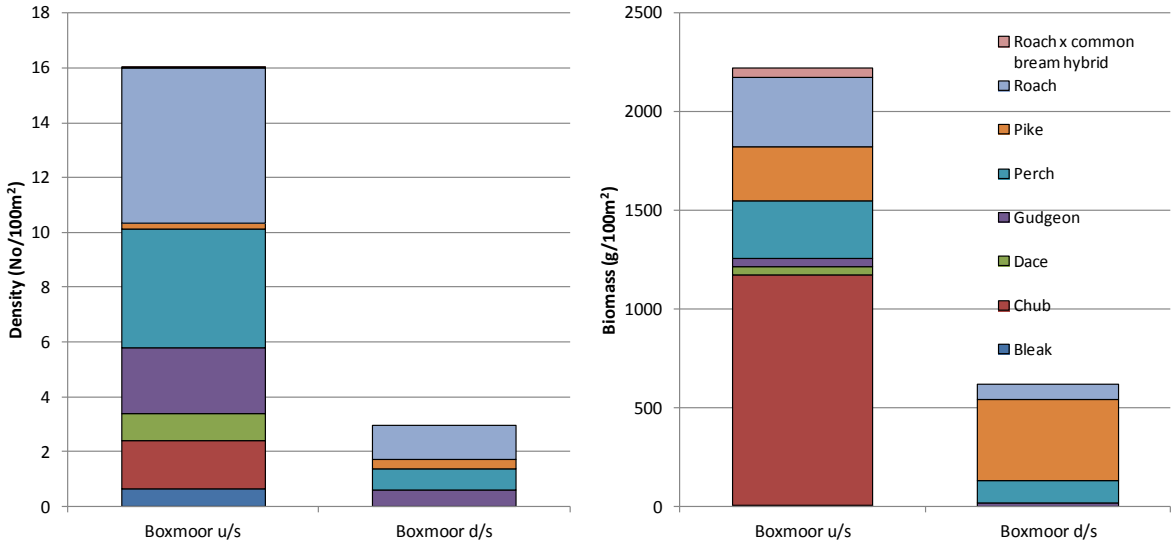

Figure 6.3: Carle and Strub density and biomass estimates for fish species >99mm for sites at Boxmoor on the River Bulbourne.

The results of the survey were surprising in that they suggest the upstream site, where habitat degradation is greater, supports by far the higher density and biomass of fish species >99mm. In fact at the downstream site estimates suggest density was just 18% and biomass 28% of that found upstream. Species diversity was also found to be higher with roach, dace, chub, bleak, perch, pike, gudgeon and the minor species bullhead, stone loach, minnow and three-spined stickleback all captured at the upstream site, whilst of these species dace, bleak and three-spined stickleback were absent from the downstream site. Roach and perch were the most abundant species at both sites, whilst chub contributed the greatest amount to overall biomass of fish at the upstream site, and pike at the downstream site.

Amongst the roach captured at the upstream site were some large adult fish. Ageing data derived from scale samples taken during the survey suggest that the largest individual of th species, measuring 305mm, was 11+ years of age. Scale samples also allow us to derive growth rates for the fish population from which they are taken. Figure 6.4 shows the growth rates for roach at different ages within this part of the River Bulbourne. Overall growth rates are average when compared to the standard growth of roach in 'southern rivers'. However the data suggests that the growth rates of younger roach between 1+ and 3+ years of age are slightly below average, whilst from 4+ years of age on the species exhibits above average growth rates.

Those species predominantly considered limnophilic, may generally seek out slower flowing water found within the upstream site. Species such as roach and bleak may have also entered the Bulbourne via overspills from the GUC boosting numbers in this section. However it is surprising that truly rheophilic species such as dace were found in higher densities upstream, whilst absent from the downstream site.

The timing of the survey may have had some influence on patterns of fish distribution, with congregations occurring pre and post spawning for some species. By late April it is likely that dace will have recently spawned, with chub possibly preparing to follow suit. Both species

are known to migrate upstream in search of spawning grounds, and stay in their vicinity post spawning. Fish passage approximately 50m above our most upstream site surveyed is restricted by the presence of a weir, potentially halting the spawning migrations of these species. Although the act of spawning for both species generally occurs where well oxygenated water flows swiftly over areas of shallow clean gravel substrate, the upstream site though lacking features that give cover, does provide greater depth of water that congregations of larger adult fish may seek out. The majority of the chub captured were large adult fish in excess of 350mm.

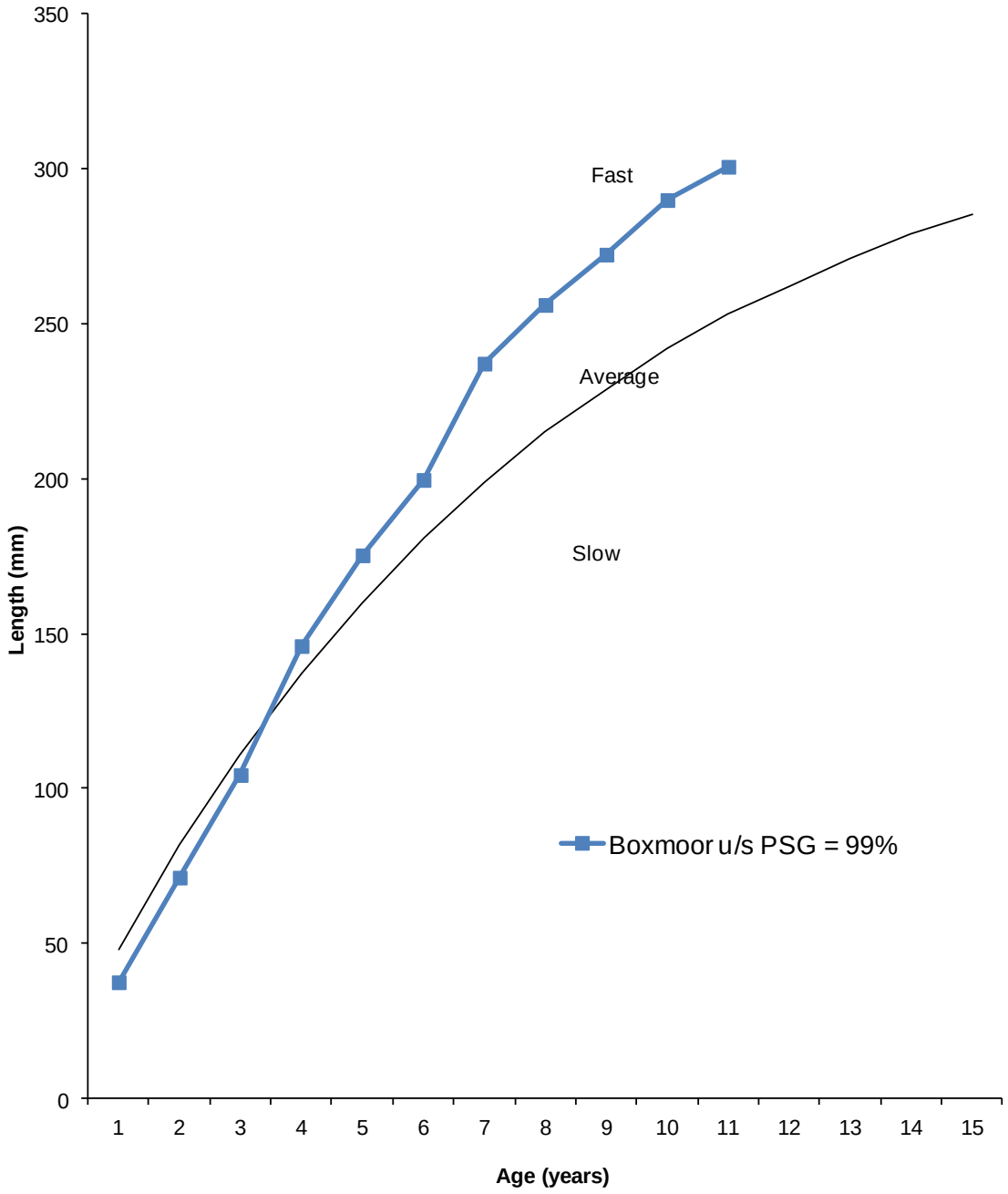

Figure 6.4: Graph to show the growth of roach in the River Bulbourne compared to the standard growth of roach in Southern rivers (National Fisheries Services unpublished data).

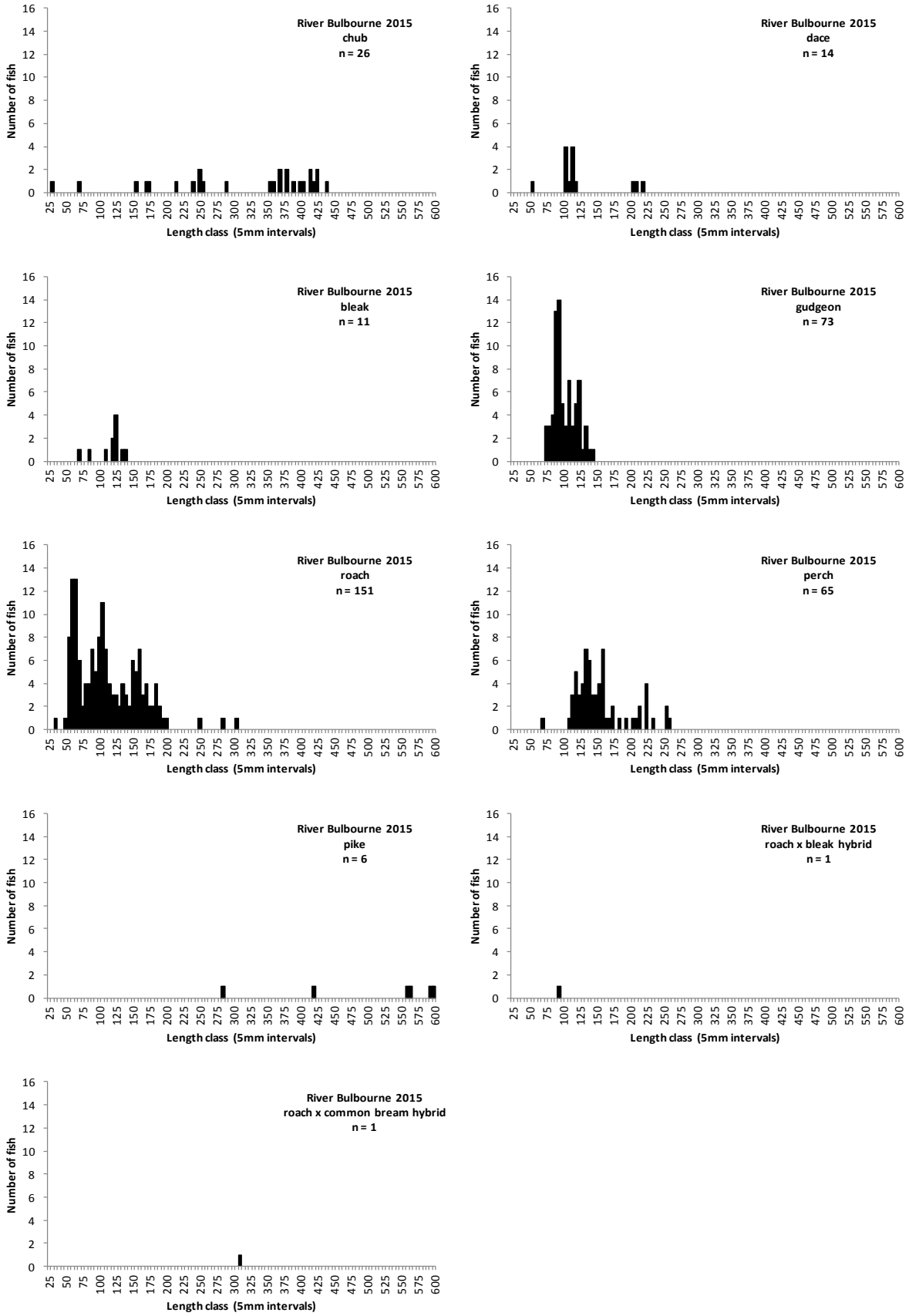

Figure 6.5: Length frequency histograms for fish species captured during 2015 surveys of the River Bulbourne

River Lee

Catchment overview

The River Lee is a chalk stream rising as springs at Waulds Bank, north-west Luton, from where it flows south-easterly through the conurbations of Harpenden, Wheathampstead, Welwyn Garden City and Hatfield. Bedrock geology is chalk, with overlying superficial deposits of clays, silt, sand and gravel. As the river enters Hertford, from Hertford Castle Weir it is altered dramatically, both morphologically and hydrologically, into a watercourse distinct from its upper reaches. Construction of the River Lee Navigation during the 18th century incorporated the majority of the old river, and has resulted in a canalised river channel comprised of some 19 pounded reaches. From Hertford it flows eastwards on through the towns of Ware and Stanstead Abbots, before veering south through an increasingly urbanised catchment and the conurbations of Broxbourne, Cheshunt, Waltham Abbey, Enfield, Walthamstow and Bromley-by-Bow before reaching its confluence with the River Thames at Limehouse Basin.

Below Hertford the River Lee system is complicated by remnants of the Old River Lea, which branch off of the main river creating side loops distinct from the navigational channel in terms of hyrdo-morphological characteristics, and providing habitat more akin to natural riverine environments. The most prominent of these loops are to be found at Amwell, downstream of Kings Weir between Cheshunt and Waltham Abbey, and in the lower reaches to the east of Hackney Marshes.

Figure 7.1: The many faces of the River Lee; Upper River Lee at Woolmers Park (top left), loops of the old river channel below Hertford at Amwell (top right) and Fishers Green (bottom left), and the Lee Navigation at Picketts Lock (bottom right).

Water Framework Directive classifications

Waterbody	Fish	Invertebrates	Macrophytes and phytobenthos	Ammonia	Dissolved Oxygen	Phosphate
Lee (from Luton to Luton Hoo Lakes)	Bad	No data	No data	Good	Poor	Good
Lee (from Luton Hoo Lakes to Hertford)	Good	Good	No data	High	High	Poor
Lee Navigation (Hertford to Fieldes Weir)	Good	Good	Moderate	High	High	Moderate
Lee Navigation (Fieldes Weir to Enfield Lock)	Good	Good	Moderate	High	High	Poor
Lee Navigation (Enfield Lock to Tottenham Locks)	No data	Moderate	Bad	High	High	Poor
Lee (Tottenham Locks to Bow Locks/Three Mills Locks)	Bad	Moderate	Moderate	Moderate	Bad	Poor

Table 6: Water Frame work Directive 2015 classifications for fish and some of the other key elements affecting fish populations for River Lee WFD water bodies. *Classification based on combined macrophyte and phytobenthos data.

Main pressures affecting fish populations

Water quality: In the upper reaches above Luton Hoo lakes water quality is likely to limit fish populations with dissolved oxygen classified as 'Poor' under WFD in 2015. In the lower reaches below Tottenham Locks significant inputs of sewage effluent downstream of Deephams sewage treatment works, coupled with diffuse pollution from urban run-off are particularly detrimental, leading to depleted dissolved oxygen levels (classified in 2015 as 'Bad' within the waterbody), elevated Ammonia levels ('Moderate') and high levels of phosphate ('Poor').

Morphology: Fish populations are heavily impacted upon by impounding structures. Dotted throughout the course of Upper River Lee there are 32 such structures, primarily weirs, whilst the river below Hertford is significantly affected by the large number of locks and weirs created in order to facilitate navigation or regulate flow. These create barriers to fish migration essential for the completion of many species life cycles.

Hydrology: Impacted upon by impounding structures, groundwater and surface water abstraction. The creation of the Lee flood relief channel between Ware and Stratford in east London has also significantly altered the hydrological regime of the Lower River Lee.

Non-native species: Established populations of non-native crayfish including the American signal, Spiny-cheeked and Virile are present throughout the Lower River Lee and Navigation. These may impact upon fish populations through increased competition for resources, degradation of habitat and direct predation upon both juvenile fish and eggs. The degree to which their presence impacts directly upon native fish populations is as yet not fully understood.

Upper River Lee

National Fisheries Monitoring Programme results 2015

The Environment Agency currently monitor one site at Wheathampstead annually, with an additional five sites surveyed triennially which are next scheduled for 2016.

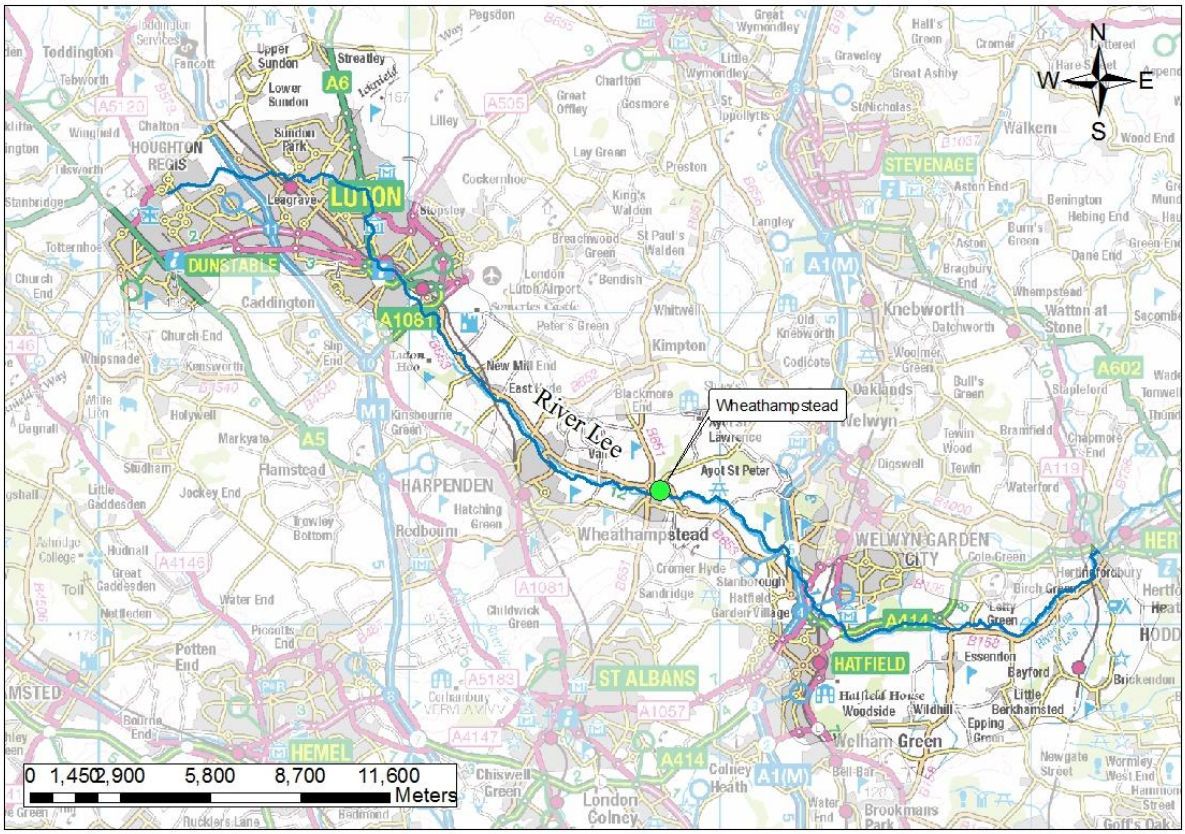

Figure 7.2: Upper River Lee catchment showing the location of Wheathampstead fisheries monitoring site.

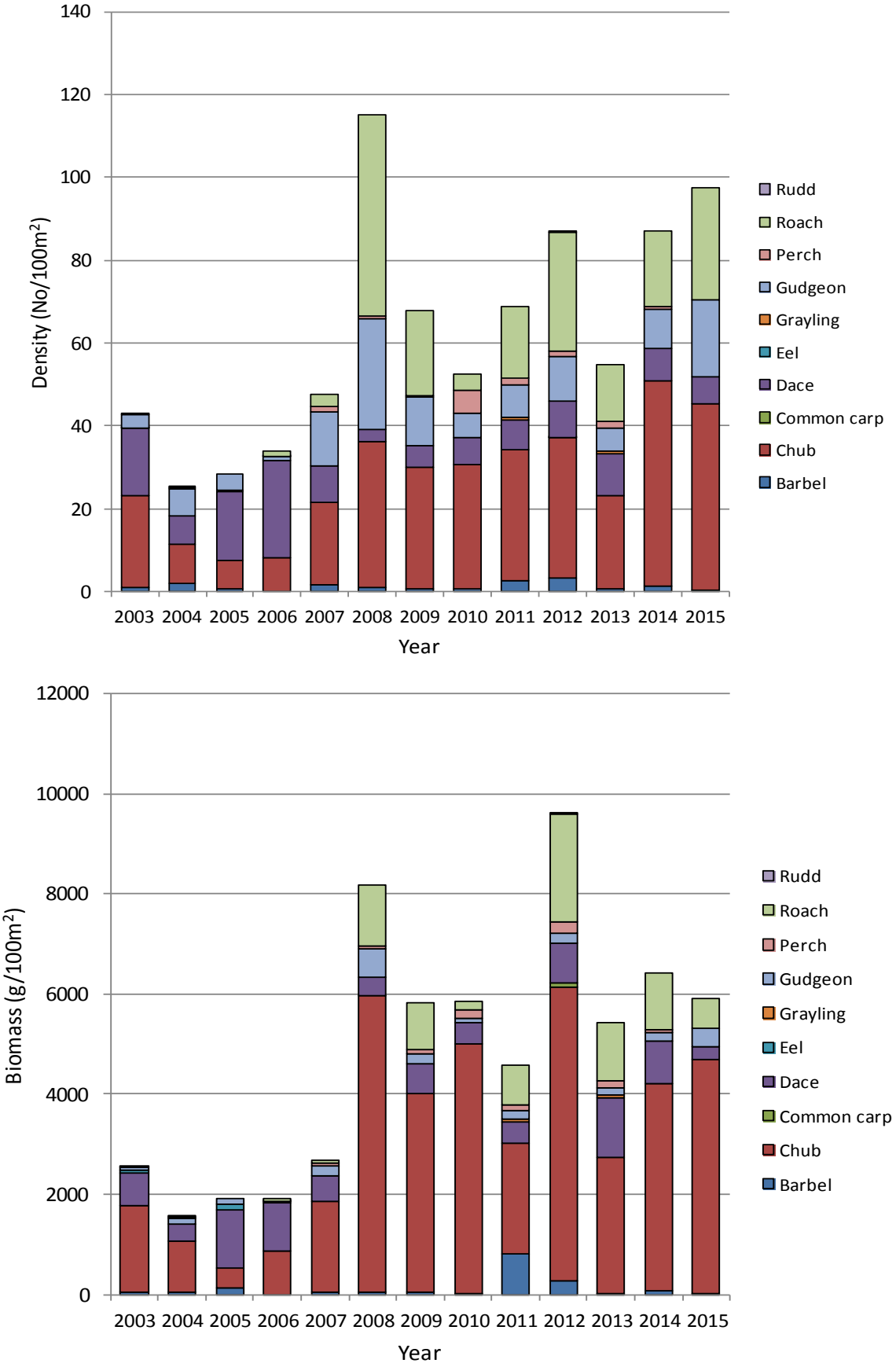

Figure 7.3: Carle and Strub density and biomass estimates for fish species>99mm at Wheathampstead 2003 – 2015.

Our survey site at **Wheathampstead** is set within recreational land controlled by the parish council. The site provides habitat typical of much of this part of the River Lee. The site is shallow throughout, with water levels being particularly low at the time of surveying in July 2015. The flow regime consists for the most part of long shallow runs and glides over a predominantly gravel substrate. Reduced management has allowed marginal and riparian vegetation to flourish in recent years, and this provides additional habitat for both fish and prey organisms to utilise. Shading is limited with some cover provided by overhanging trees at the downstream extent of the site.

This part of the Upper Lee is incredibly productive. Wheathampstead consistently produces the highest densities of fish of any of the sites we routinely monitor within the Hertfordshire and North London Area, with 2015 proving to be no different. A total of 839 fish were captured during the survey. Species diversity was relatively low with chub, barbel, dace, roach and gudgeon as well as the minor species minnow and stone loach captured. Of these, chub are the dominant species within this part of the Upper Lee, accounting for 46% of the total density and 79% of the total biomass of fish species >99mm at the site. The shallow nature of the site means it is more suited to the juvenile life stages of larger species such as chub and barbel. The mean length of the 466 chub captured during the survey was 155mm, whilst for barbel it was just 95mm. Shallow un-shaded water such as found throughout this site equates to warm water during the summer months, and this is sought by juveniles of a variety of species as it facilitates faster growth rates in poikilothermic organisms, which are reliant on the ambient temperature of their environment to drive their metabolism. Larger individuals of these species are likely to seek out sections of river offering greater cover and depth of water. A short distance downstream of our site is Marford Farm. Offering deeper water the fishery is renowned for the numbers of large barbel and chub it supports.

Large dace have been present in good numbers in previous years, and although the species is well suited to shallow fast flowing water, the extent to which water levels had fallen in comparison to 2014, may be reason enough for these larger individuals to seek deeper water outside of our survey site.

Length frequency histograms (Figure 7.4) suggest a single strong year class of roach measuring between 90mm and 130mm make up almost the entirety of the population represented within the catch. Fish of this size have been aged to 2+ years of age suggesting they are the progeny of spawning in 2013.

Estimates from 2015 suggest density of fish >99mm is the second highest to date. Density of fish >99mm peaked in 2008. Post 2006 fish density has increased considerably, with roach becoming more prevalent. Increased abundance of species >99mm in 2008 may be the result of favourable hydro-climatic conditions in 2006, a particularly warm year in which low flows in both the summer and following winter may have facilitated increased growth and survival rates in young of year fish. Analysis of growth rates derived from scale samples taken during our surveys, suggests that roach and chub within this part of the River Lee typically exceed 99mm at 2+ years of age, meaning the 2006 year class is first present within the results of the 2008 survey.

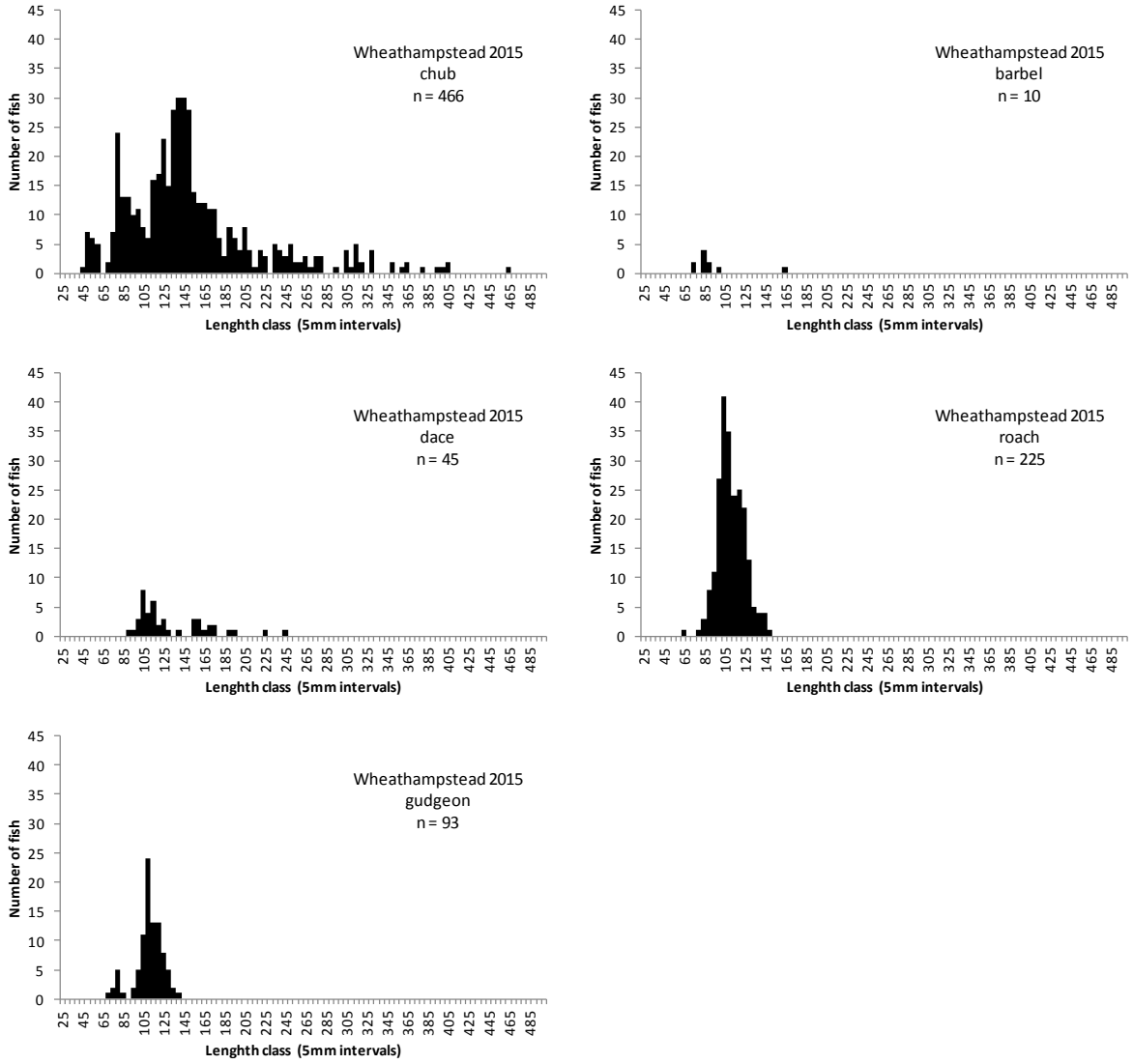

Figure 7.4: Length frequency histograms for fish species captured during the 2015 survey of Wheathampstead.

Lower River Lee

Four surveys were carried out on remnant loops of the old river channel in 2015 as part of NFMP monitoring. A fifth survey due to be conducted on the old river channel at Hackney Marshes was cancelled due to high flows. In addition an investigative survey of Kings Weir fishery was conducted to give an insight into the status of existing fish stocks, and feed into ongoing efforts to enhance the fishery. WFD surveys at Dobbs Weir on the Lee Navigation and the Powder Mill Cut complete the 2015 programme for the River Lee below Hertford.

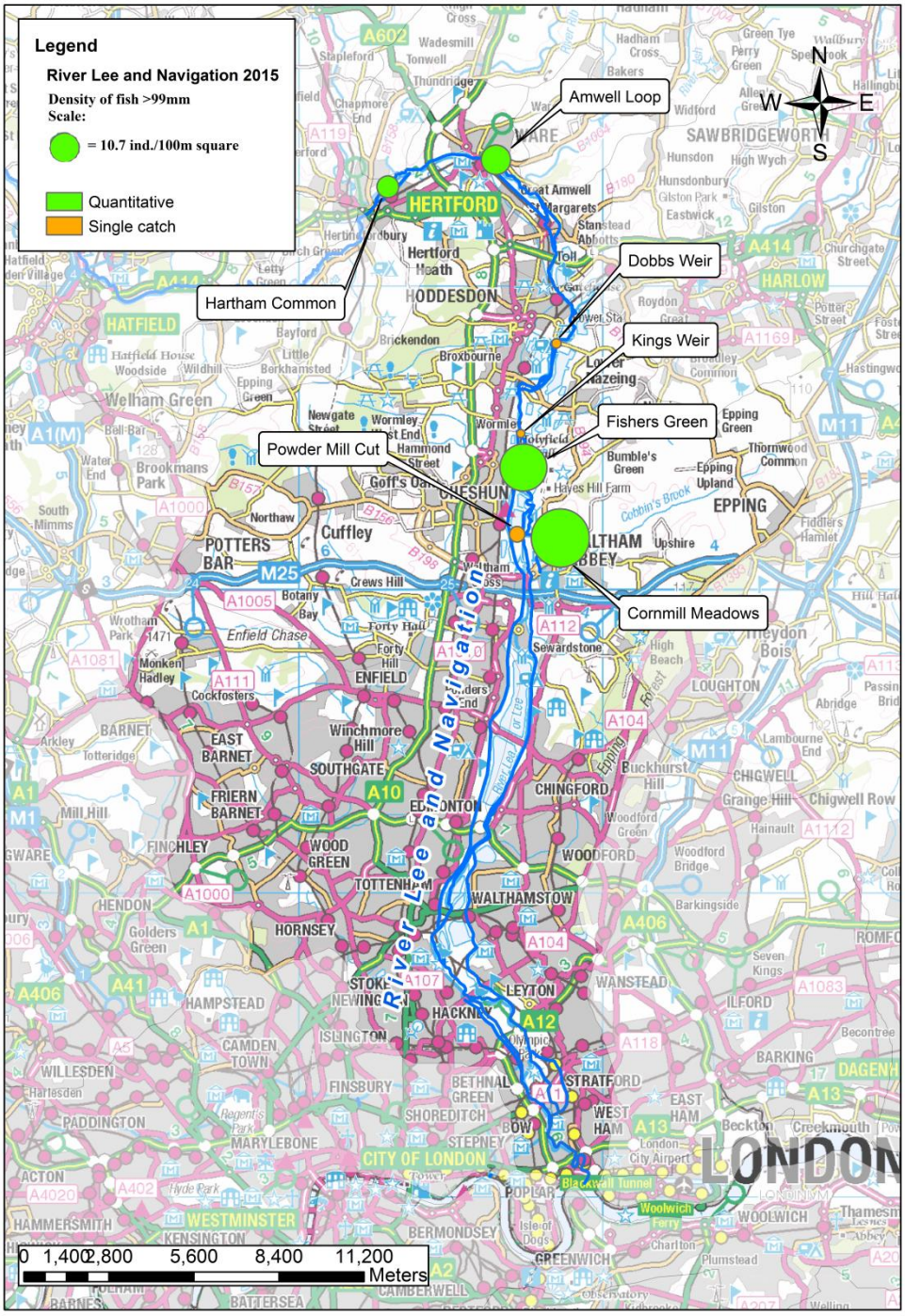

Figure 7.5: Lower River Lee catchment showing location and comparative densities of fish >99mm at Environment Agency fisheries monitoring sites 2015.

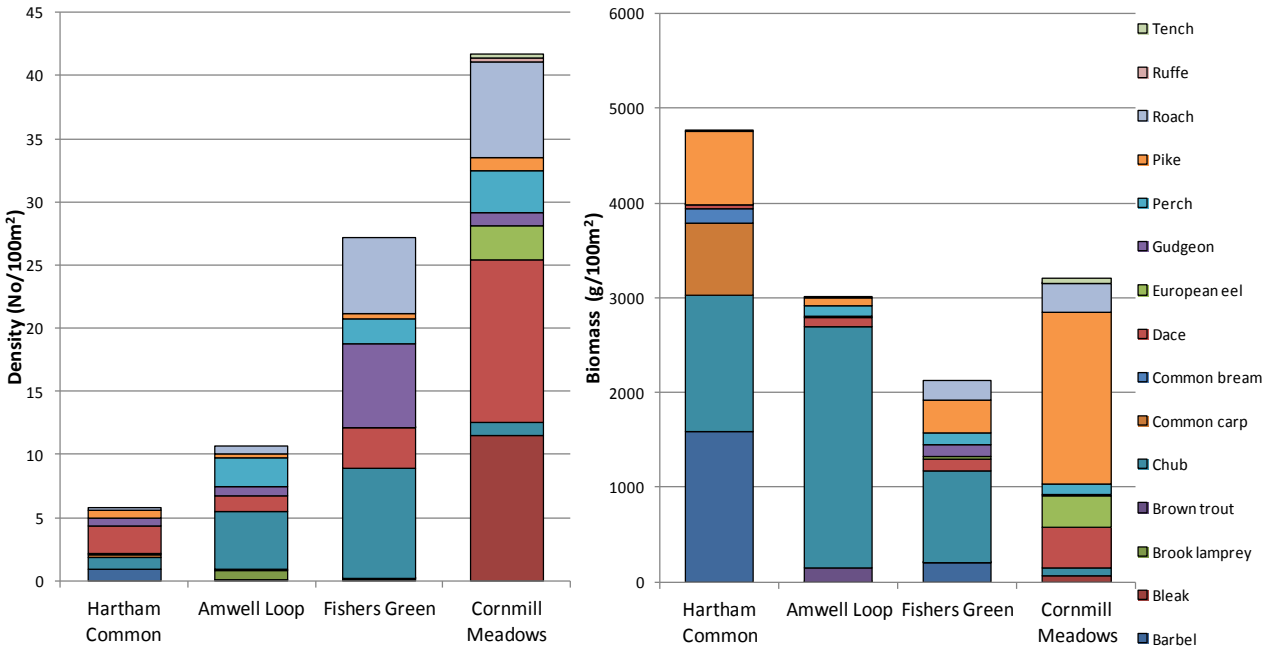

Figure 7.6: Carle and Strub density and biomass estimates for fish >99mm at Lower River Lee fisheries monitoring sites 2015.

The fish population within side loops of the Lower River Lee are typically diverse. In 2015 a total of 15 major fish species and the minor species minnow, stone loach and bullhead were captured during NFMP surveys. Complex interlinking of old river channel, navigable channel and relief channel throughout the Lower Lee system provide significant contrasts in channel characteristics and prevailing hydrology within small spatial scales. Consequently species richness is enhanced within the side loops of the Lower Lee as species which may not be suited to hydrological extremes, such as limnophilic species typically inhabiting the navigation, may migrate intermittently in and out of these sections of river during favourable river conditions.

At **Hartham Common** our survey site is situated on a section of old river channel which diverges from the navigation above Folly Bridge, Hertford, before rejoining approximately 1.5 km downstream. The confluences of firstly the River Beane, and then River Rib, converge with the River Lea within this short section. The site is bordered by park land to the true left and a wooded island to the right. Since the 2014 survey it is evident that significant work had been carried out to clear both trees which had fallen into the river channel and some riparian vegetation. The downstream extent of the site is shaded by tree canopy, which progressively opens heading upstream allowing more light to reach the river channel. Despite this macrophytic growth is limited, with cover provided by depth of water and remnant areas of woody debris.

Density of fish species >99mm was the lowest of all the sites surveyed on the Lee below Hertford in 2015, dace being the most abundant species. The site consistently produces specimen chub and barbel, and 2015 was no different. Estimated biomass at the site was the highest since 2002, primarily as a result of the number of large barbel and chub

captured. Barbel were the highest contributing species to biomass, with thirteen barbel captured, the highest number to date. All of these barbel were adult fish with a size range of between 392mm and 634mm. Juvenile barbel are likely to utilise shallower areas of river outside of our survey site. The sites proximity to the Lee Navigation and increased connectivity with the wider watercourse following rebuilding of the weir below our site in 2008 in order to improve fish passage, may explain why species such as carp and common bream have been found more regularly in our recent surveys.

Figure 7.7: barbel captured during the 2015 survey of Hartham Common

South east of Ware the **Amwell Loop** diverges from the Lee Navigation at Tumbling Bay Weir. From here the old river channel flows approximately 3km before rejoining the navigational channel below Stanstead Lock. Within this reach it is joined by the confluence of the River Ash. Our survey site sits towards the upstream extent of the loop. Fishing rights at this point are controlled by Ware Angling Club. Further downstream the fishing is controlled by the Amwell Magna Fishery fly fishing club.

Riffle pool sequences are evident throughout the top section of this part of the old river. Overhanging riparian vegetation creates marginal cover throughout the site, with trailing branches from larger trees creating areas of sanctuary for larger fish. In response to concerns from anglers regarding flow within the Amwell Loop, Tumbling Bay Weir was lowered in early 2015, allowing more water to be drawn from the navigation into the loop. Increased flow and velocity of water subsequently increased entrainment of fine sediments and has led to cleaner gravels throughout the site in comparison to when last surveyed in 2013. This is likely to benefit rheophilic gravel spawning coarse species such as chub and dace.

Chub are the dominant species at the site both in terms of density and biomass. Large individuals of the species are regularly captured. It was encouraging to see greater numbers of fish of between 130 – 200mm in length featuring in the catch during the 2015 survey than in the past few years of surveys. The coarse species roach, dace, gudgeon, pike, perch, bleak and brook lamprey also featured in the catch, whilst a single brown trout was captured.

At **Fishers Green** the results of our surveys have been highly variable, with large fluctuations in both the density and composition of the fish population present. This section of the old river which runs from Kings Weir to its confluence with the Lee Flood Relief channel adjacent to Seventy Acres Lake, is relatively wide and deep throughout, with our site situated on one of the shallower areas of the river throughout this part of the Lea Valley Park. Even so the site is difficult to survey efficiently, and population estimates obtained from the 2015 survey have a low degree of confidence attributed to them. At the time of surveying in July 2015, water levels were noticeably lower than in 2014. Fast runs and glides predominate over a substrate consisting of gravels and sand, with dense submerged and emergent macrophyte beds dotted throughout the river channel. Density estimates from the 2015 survey suggest chub are the most abundant species >99mm at the site, followed by roach, gudgeon and dace. The majority of chub captured were below 200mm in length, which is encouraging, and suggests that the species is successfully recruiting within this part of the Lee.

Roach were again captured at the site having been absent in the 2014 survey, with two distinct size classes of roach of between 60 – 90mm and 110 – 150mm making up almost the entirety of the sampled population. The proximity of this section of the Old River Lee to the Flood Relief Channel means that species such as roach are likely to migrate between the two watercourses, especially when hydrological conditions are adverse within the confines of the more natural old river channel. Figure 7.8 shows how the density of roach has fluctuated at the site between 2006 and 2015, as well as mean winter flows across the time period. Most striking is the absence of roach from the 2014 survey following the highest winter flows across the time period, and the highest densities of roach in 2012 corresponding to the lowest mean winter flows over the preceding winter.

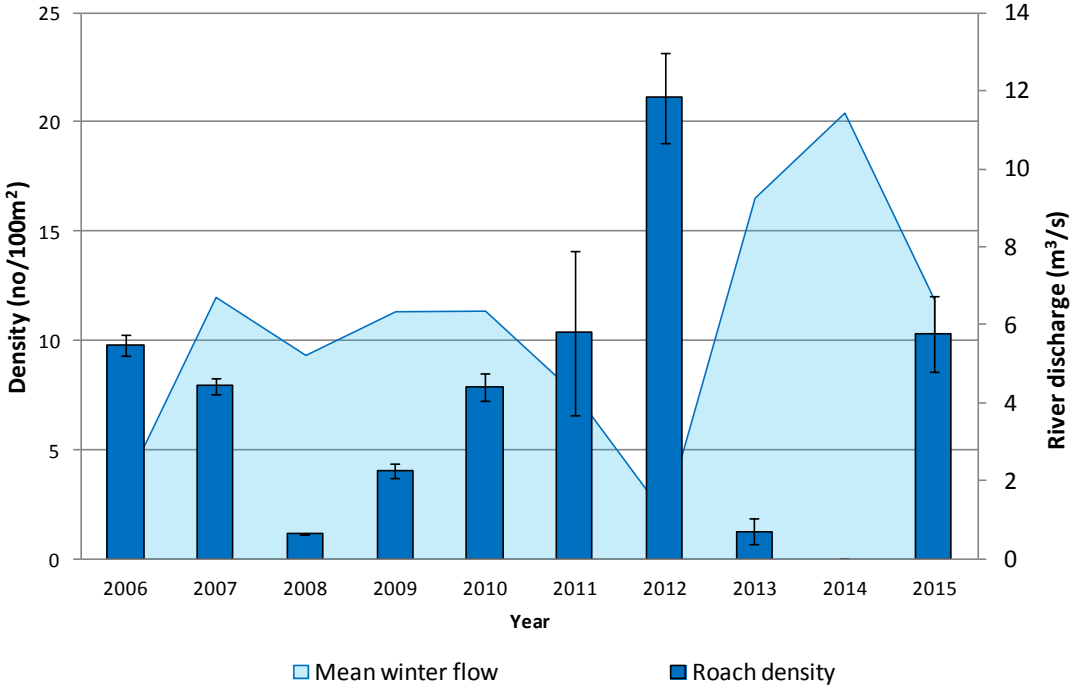

Figure 7.8: Carle and Strub density estimates for roach (+/- 95% confidence limits) 2006 - 2015 at Fishers Green, showing mean winter flow (Oct of previous year to March of year) based on data from the Environment Agency Fieldes Weir gauging station.

The single barbel captured during the 2015 survey is believed to be the same fish captured in 2014, and was taken from almost exactly the same spot suggesting this individual is highly territorial.

Figure 7.9: Barbel captured during the 2015 survey of Fishers Green

The Old River Lea at **Cornmill Meadows** supports a diverse fish population, and yielded the highest densities of fish of any of the sites surveyed on the Lower River Lee in 2015. The site we survey is an anomaly in terms of the habitat it possesses when placed in the context of this part of the Old River Lea as a whole. Our site is situated from below the weir pool where the old river branches off of the Cornmill Stream, and encompasses the entirety of an isolated area of river in which habitat enhancement work has been carried out. Introduction of gravels has increased variation of depth and flow, absent from much of this part of the Old River Lea, which in the main is over wide lacking significant flow, with substantial silt deposition evident throughout. The diversity in habitat draws a multitude of species. Through the middle section gravel riffles and shallower glides are utilised by dace, which were the most abundant species. Deeper water found at the upstream and downstream extents of the site is utilised by larger species such as pike which dominate fish biomass, as well as predominantly limnophilic species such as tench which regularly feature in our surveys of the site.

Figures 7.10 and 7.11 show estimated mean density and biomass of fish species captured during the 2015 Lower Lee survey and comparative long term means. Estimates of species density suggest that for almost all species densities in 2015 are higher than the long term mean, the main exception to this being roach.

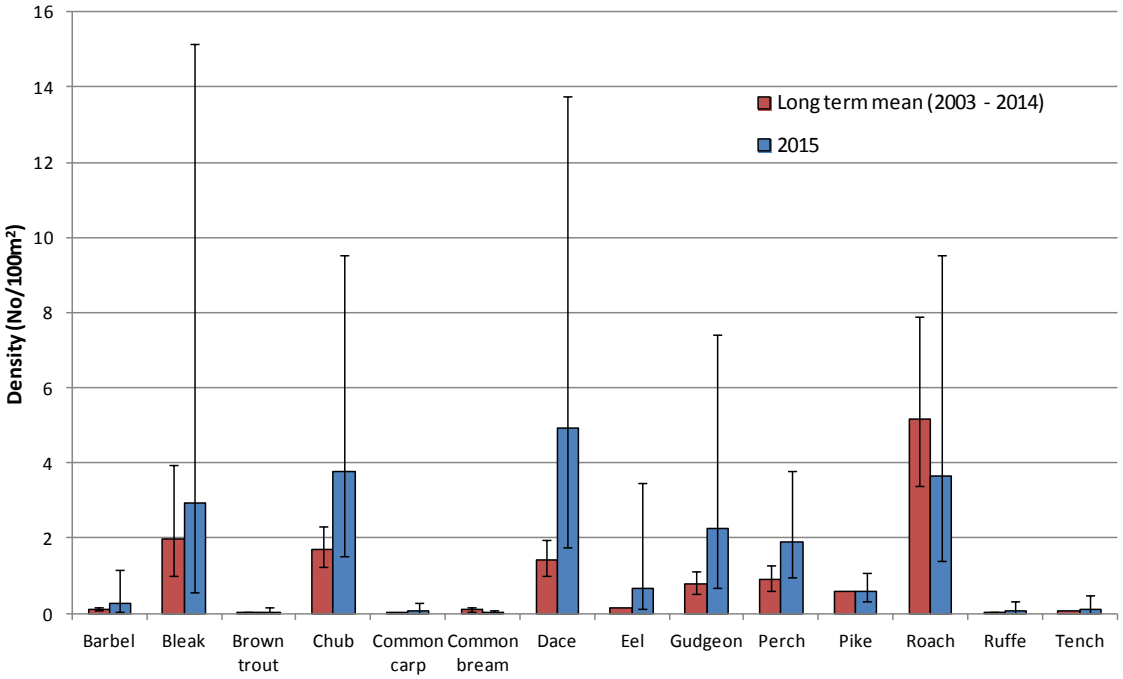

Figure 7.10: Carle and Strub mean density estimates (+/- 95% Confidence Intervals) for fish species >99mm captured during the 2015 Lower River Lee survey and comparative long term mean.

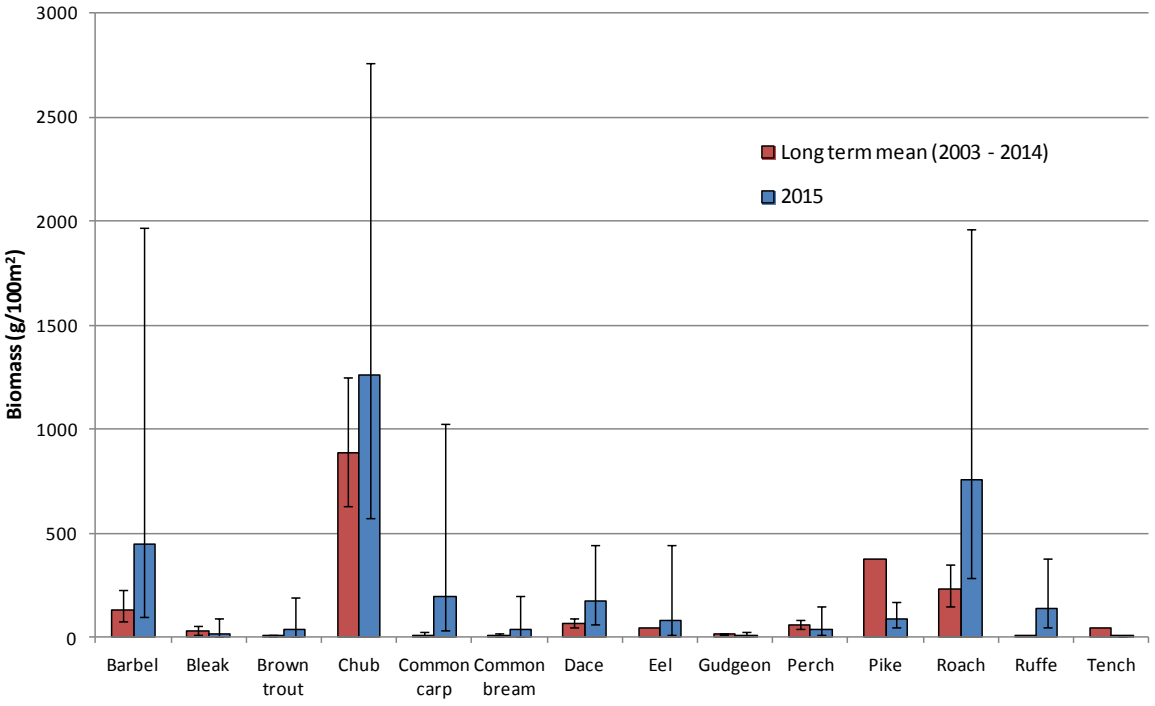

Figure 7.11: Carle and Strub mean biomass estimates (+/- 95% Confidence Intervals) for fish species >99mm captured during the 2015 Lower River Lee survey and comparative long term mean.

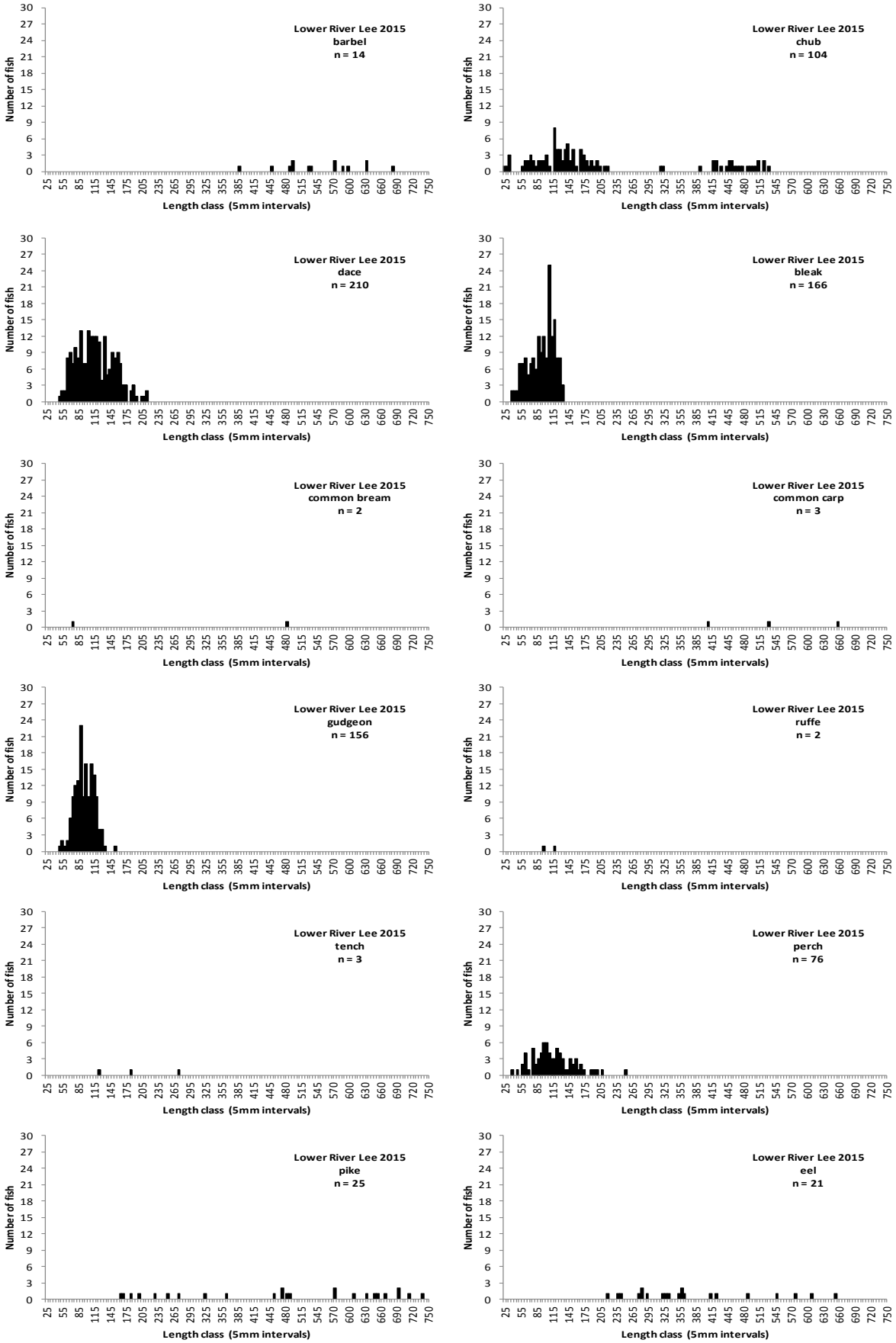

Figure 7.12: Length frequency histograms for fish species captured during 2015 NFMP surveys of the Lower River Lee.

Water Framework Directive survey results 2015

The two WFD surveys at Dobbs Weir and Powder Mill Cut were carried out in order to provide classification data for the waterbody Lea Navigation (Fieldes Weir to Enfield Lock).

Site	Chub	Bleak	Roach	Perch	Pike	Tench
Dobbs Weir	2	2	25	2		
Powder Mill Cut			21	12	5	8

Table 7: Number of each species captured in a single electric fishing run at WFD monitoring sites within the Lea Navigation (Fieldes Weir to Enfield Lock) waterbody surveyed in 2015.

Surveys of relatively deep navigational channels are amongst the most difficult from which to achieve efficient, representative sampling of the resident fish population. Both of the sites were surveyed using electric fishing from a boat as the survey methodology.

At Dobbs Weir our site on the navigational channel is situated adjacent to the Lee Valley Parks car park opposite the Fish and Eels public house. The channel here provides limited habitat for fish populations with cover provided by moored boats and patches of overhanging riparian vegetation on the true left. The catch was dominated by small roach, with perch, chub and bleak also featuring. Better habitat for fish populations can be found a short way upstream where the channel widens and increased macrophyte growth is evident.

As the name suggests the Powder Mill Cut is a short channel branching off to the east of the Lee navigation as it flows through the Lee Valley Park in Cheshunt. Originally created to aid transport of gun powder from the gun powder mills found within this area, the channel is now full of dense submerged macrophyte beds and filamentous algae. This submerged cover and static flow makes the site well suited to tench, and historically the site has produced good numbers, and is especially productive for juveniles of the species. Roach were the most abundant species, followed by perch.

Figure 7.13: The Powder Mill Cut

Kings Weir Investigation

The famous Kings Weir fishery on the Old River Lea has a history of producing a number of species to specimen size, but is particularly renowned for the barbel and chub it holds.

The Kings Weir Angling Club have raised concerns regarding barbel numbers within this part of the River Lea in recent years, with the perception being that low levels of natural recruitment was occurring. In order to mitigate for this and enhance the barbel population within the wider fishery, basic habitat improvement works were carried out on an area of back channel adjacent to Kings Weir in 2013, which had been identified as potentially providing habitat suitable for juvenile barbel. This subsequently received a stocking of 400 barbel of between 150mm – 200mm donated by the Barbel Society, and a further 500 barbel of a similar size from the Environment Agency's Calverton fish farm in December 2013. An investigative survey of the back channel in 2014 resulted in the capture of just three barbel in this size class, indicating wider distribution of these fish throughout the River Lee system is likely to have occurred.

In June 2015 two surveys were conducted targeted at establishing what effect these measures may have had on the barbel numbers throughout the wider fishery, as well as providing an insight into the fish stocks present.

A timed electric fishing survey of the large weir pool was conducted by boat, the results of which are shown as Catch Per Unit Effort (CPUE) in Figure 7.14. The efficiency of this survey was questionable due to the depth of water present within the weir pool, with the limited effective range of the electric fishing equipment used likely to have resulted in an under representation of the true fish population present. Total numbers of fish captured were low. Barbel and chub were absent from the catch, with common bream being the most abundant species, followed by pike. Barbel in particular are difficult to capture efficiently in deep water, and so it is not entirely surprising that they did not feature, as the species is likely to hug the bottom in the particularly deep water found close to the weir sill. The highlight of the survey was the capture of a large pike, which was weighed at an impressive 29lb 6oz.

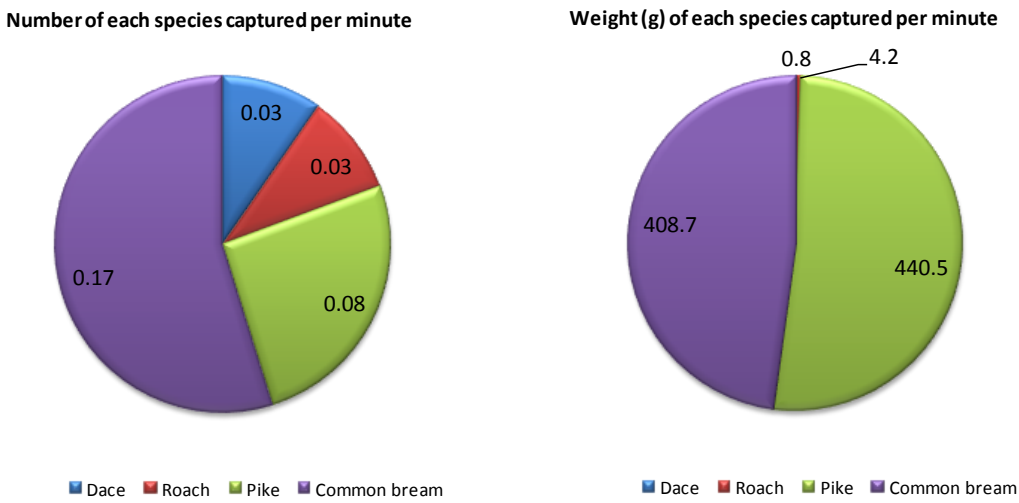

Figure 7.14: Catch per Unit Effort results showing number and weight (g) of fish species captured per minute during the 2015 survey of Kings Weir weir pool.

A second survey encompassing a length of approximately 330m of the river channel immediately downstream of the weir pool, replicated the area of river covered when last surveyed by the Environment Agency in June 1992. The comparative results of the two surveys are shown in Figure 7.15. The river here is relatively wide and deep, and necessitated electric fishing from a punt drawn from the banks by ropes, rather than being able to wade the site as was the case when surveyed in 1992. Potential habitat for fish species throughout this section of river is predominantly provided by marginal tree cover which in patches significantly encroach the river channel, the submerged trailing branches of which create areas of dense cover and debris rafts which are havens for a variety of fish species.

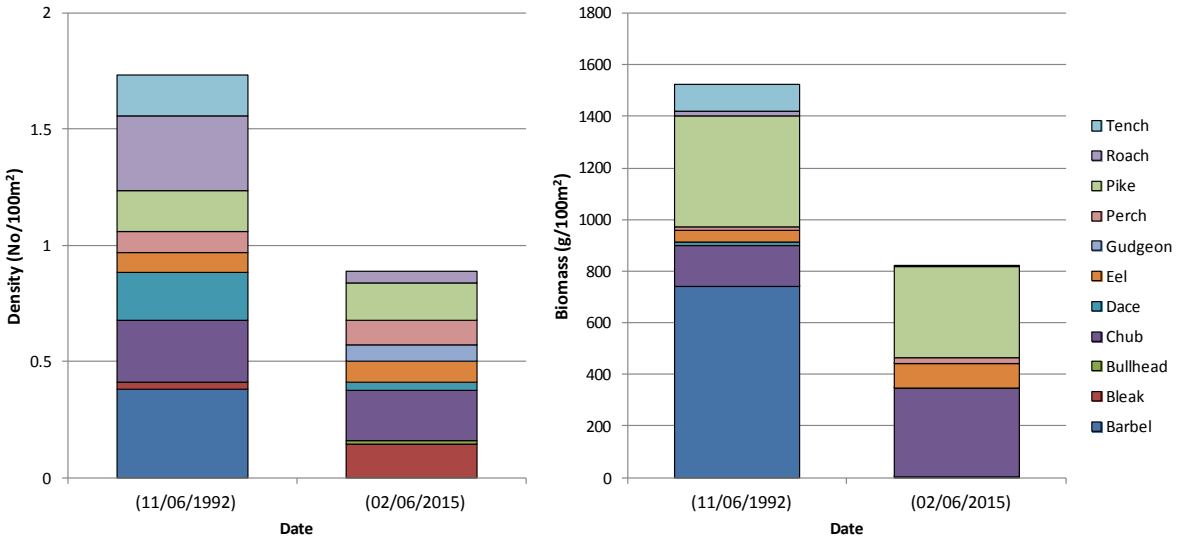

Figure 7.15: Comparative density and biomass of fish species at Kings Weir 1992 and 2015 based on a single electric fishing catch

Species diversity was higher than found within the weir pool, with eight species captured as well as the minor species bullhead and minnow. Chub were the most abundant species, with some impressive specimens up to an estimated 6lbs in weight captured.

Upon comparison of the 1992 and 2015 survey results, although not quantitative, it would appear that density and biomass of fish species has declined within this part of the River Lea. However it is important to bear in mind differences in survey technique. Higher water levels in 2015 necessitated the need to survey by boat, whilst the 1992 survey team were able to wade the entirety of the site which is likely to have increased their coverage of the river channel and catch efficiency.

In 2015, as with the weir pool, barbel were absent from the catch with none of the stocked fish captured. A single large individual was spotted but managed to evade capture. Survey efficiency may have been affected by depth of water, particularly so when trying to pick up relatively small benthic fish such as juvenile barbel, as well as the inherent difficulty in drawing fish out from amongst dense marginal cover. In the 1992 survey barbel were the most abundant species with 13 captured. These were all large adult fish ranging from between 445mm and 695mm in length. The absence of smaller barbel suggests that this part of the River Lea may not be best suited to the juvenile life stage, which may typically seek out areas of shallower fast flowing water.

It is also worth noting that at the time of the 2015 survey, local angler knowledge suggested that the majority of the barbel within this part of the River Lea may have migrated downstream to areas of shallower water in order to spawn, and is a plausible explanation for their absence from the catch.

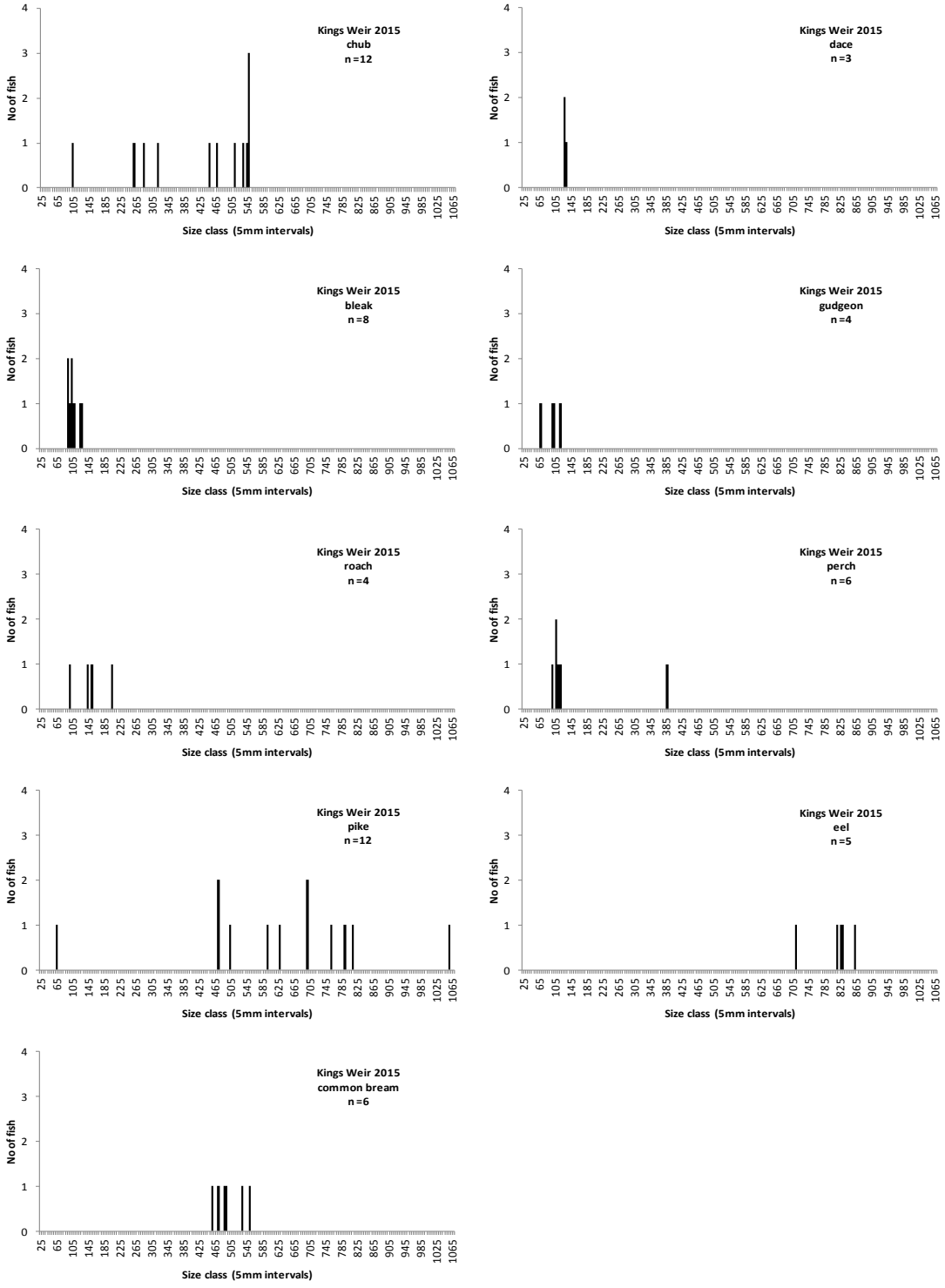

Figure 7.16: Length frequency histograms for fish species captured during investigative surveys of Kings Weir 2015.

Small River Lee and Turnford Brook

Catchment overview

Diverging from the Old River Lea at Aquaduct Lock, the Small River Lee flows south along the western border of the Lee Valley Park passing through Turnford Marsh, Cheshunt Marsh, Holdbrook and Rammey Marsh on route to its convergence with the Lee Navigation below Enfield Village Island. As the river flows adjacent to the North Metropolitan Pit within the River Lea Country Park, it is joined by its tributary the Turnford Brook.

Figure 8.1: The Small River Lee at Windmill Lane

Water Framework Directive classifications

Waterbody	Fish	Invertebrates	Macrophytes and phytobenthos	Ammonia	Dissolved Oxygen	Phosphate
Small River Lee (and tributaries)	Good	Moderate	Good	Good	Poor	Poor

Table 8: Water Framework Directive classifications for fish and some of the other key elements affecting fish populations within the Small River Lee (and tributaries) waterbody 2015.

The fish population within the Small River Lee and its tributaries is classified as being at 'Good' status. However the waterbody is failing for many of the elements key to supporting a healthy fish population, and in particular physico-chemical elements such as dissolved oxygen and phosphate.

Main pressures affecting fish populations

Dissolved oxygen and Phosphate: Due to the urban nature of the catchment through which the river flows, significant diffuse and point source inputs from misconnections and road runoff are the key detrimental factors affecting water quality.

Morphology: Much of the Small River Lee and its tributaries have been subject to re-sectioning and movement of the river channel from its original course. This has led to an unnatural hydrological regime, with long sections of straightened and over-widened river channel, and subsequent settlement of fine particulate matter.

Water Framework Directive survey results 2015

Three sites were surveyed within the waterbody for WFD classification purposes in 2015, two on the Small River Lee and one on its tributary the Turnford Brook.

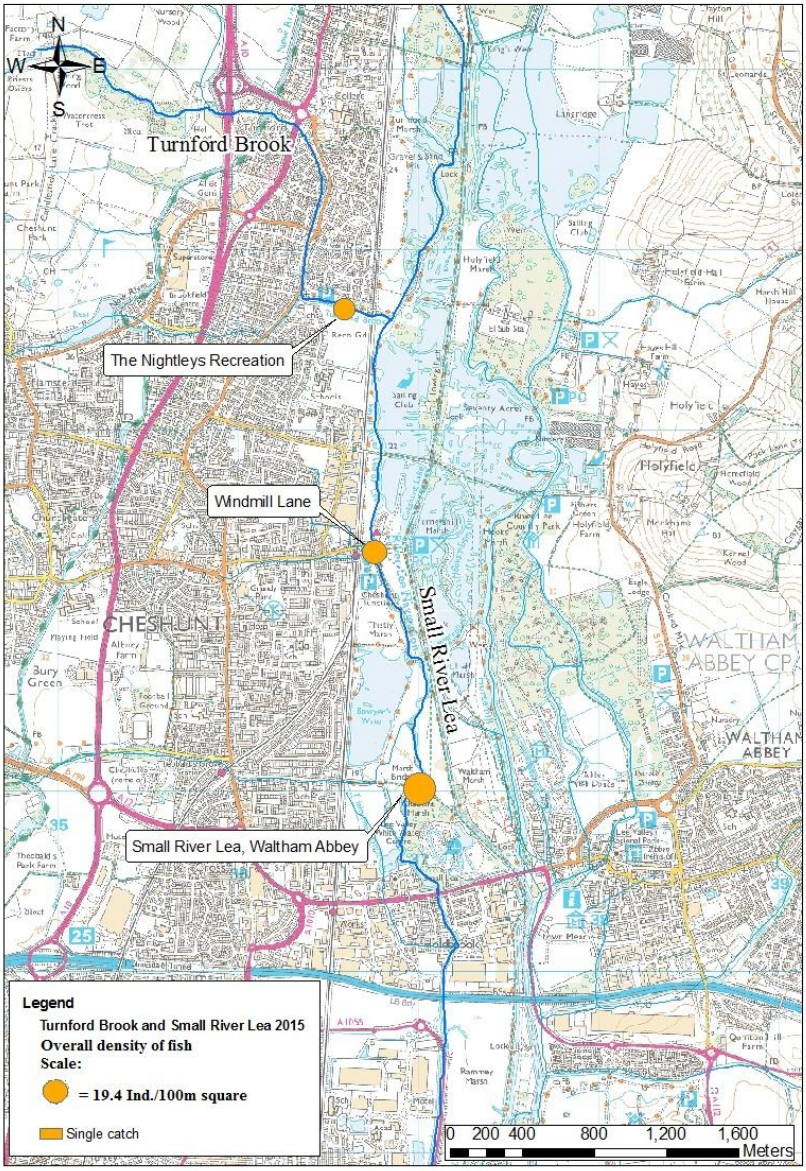

Figure 8.2: Location and comparative density of fish >99mm at fisheries monitoring sites on the Small River Lee and Turnford Brook 2015.

Site	3-spined stickleback	Bullhead	Bleak	Chub	Dace	Eel	Gudgeon	Perch	Pike	Roach	Rudd	Stone loach	Tench
The Nightleys Recreation		1		1	1	2	1	28	3	26		3	1
Windmill Lane	3	5			1		11	8		29	1	10	
Small River Lee, Waltham Abbey			1	11	13		12			76			

Table 9: Number of each species captured in a single electric fishing run at WFD monitoring sites within the Small River Lee and tributaries waterbody surveyed in 2015.

Despite being largely neglected the Small River Lee and its tributary the Turnford Brook are able to sustain a diverse fish population in spite of significant habitat degradation and the chronic effects of diffuse pollution. Fish populations found at all three sites are likely to be influenced to some degree by the watercourses proximity to the lakes of the Lee valley Park, which lie within the flood plain of the Small River Lee along the majority of its course north of Holdbrook. Limnophilic species captured during the surveys, and not typically expected to reside within watercourses of this type such as rudd and tench, may well have entered during flood events.

On the Turnford Brook **The Nightleys Recreation** was found to have the most diverse fish assemblage of the three sites within the waterbody, with ten species of fish featuring within the catch. Perch were the most abundant species, and the site does provide areas of habitat suited to them, with slow flowing water and potential cover and spawning medium in the shape of tree root systems and macrophyte stands. For the majority the river channel is straight, with little variation in morphology or hydrological characteristics.

At **Windmill Lane** habitat has been altered since last surveyed in 2011. Removal of trees and riparian vegetation bordering the river channel has decreased adjacent habitat complexity, while the channelized nature of the river itself lacks heterogeneity, with significant sediment deposition meaning the substrate throughout the entirety of the site is heavily silted. The majority of fish captured during the survey came from an area of habitat created in the lee of a partially submerged tree stump. This area of slightly deeper water provided the greatest available cover found within the survey site.

The **Small River Lee, Waltham Abbey** is heavily encroached by riparian vegetation and emergent *Sparganium erectum* beds, which emerge from areas of heavy silt, and block out light preventing any significant submerged macrophyte growth. No discernible flow was evident at the time of surveying August 2015, with static water throughout the site and the river bed almost dry for a short length just downstream of the surveyed section. Topography of the river bed undulates from shallow riffle areas to wider deeper pools, in which the majority of those fish present sought refuge. Species diversity was the lowest of the three sites surveyed. Good numbers of rheophilic species were present, although roach are the dominant species at the site.

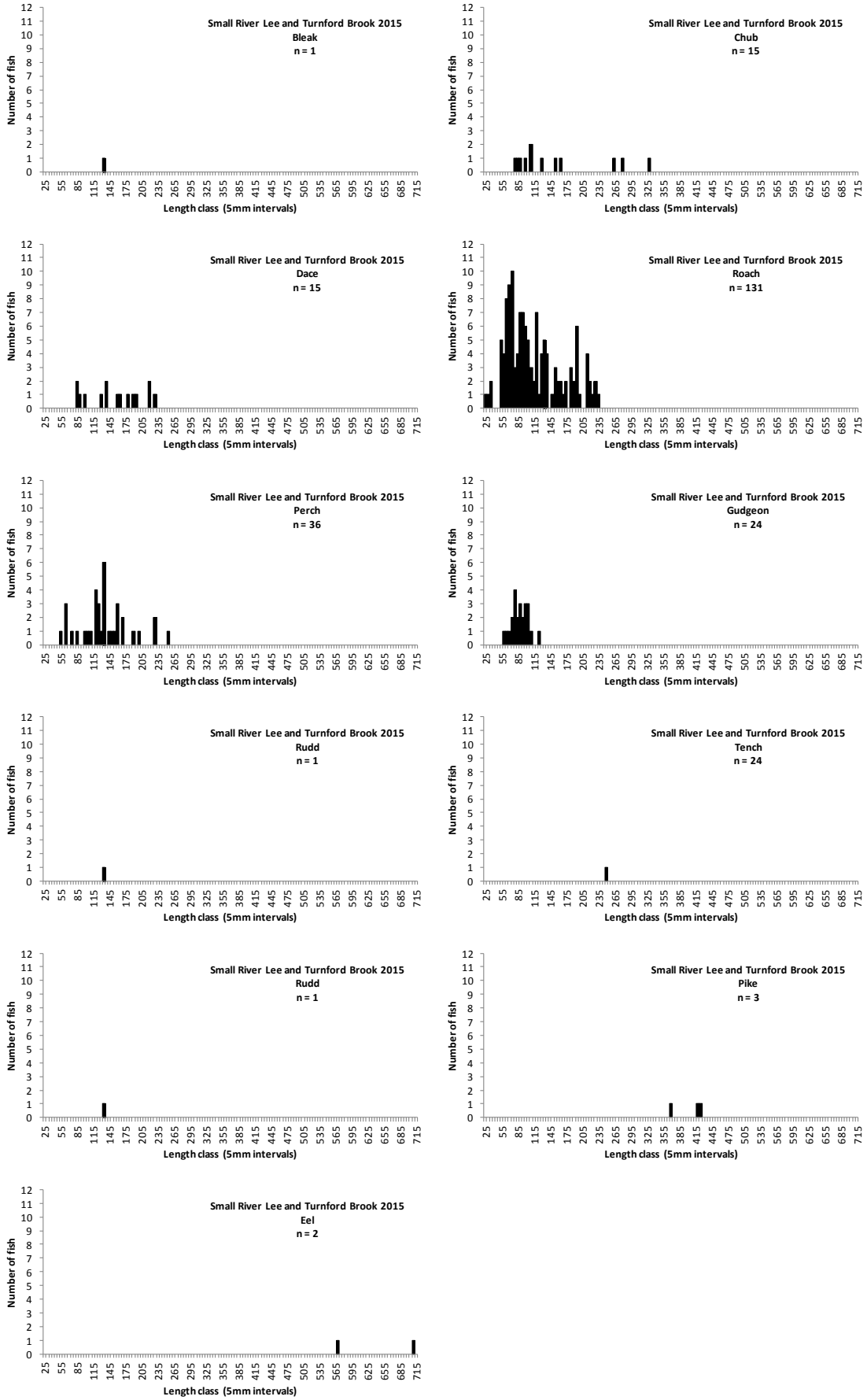

Figure 8.3: Length frequency histograms for fish species captured during 2015 surveys of the Small River Lee and Turnford Brook.

Pymmes Brook

Catchment overview

Set within the urban confines of north London the Pymmes Brook, a tributary of the River Lee, is symptomatic of many of the pressures affecting urban rivers and the fish populations they support. Originally rising in the form of the Monken Mead Brook, the watercourse takes on its Pymnmes Brook incarnation below a series of online lakes at Hadley Wood Golf Course. From here the brook flows south, south-east through Barnet, Wood Green and Edmonton before its confluence with the Lee Navigation below Tottenham Locks.

Figure 9.1: The Pymmes Brook at Arnos Park

Water Framework Directive classifications

Waterbody	Fish	Invertebrates	Macrophytes and phytobenthos	Ammonia	Dissolved Oxygen	Phosphate
Pymmes Brook upstream Salmon Brook confluence	Poor	Bad	Not assessed	Poor	Bad	Poor
Pymmes and Salmons Brooks - Deephams STW to Tottenham Locks	Not assessed	Poor	Moderate	Poor	Good	Poor

Table 10: Water Framework Directive classifications for fish and some of the other key elements affecting fish populations within Pymmes Brook waterbodies 2015.

The Pymmes Brook is split into two separate waterbodies for WFD classification. Fish populations above the point where the Salmons Brook joins the Pymmes are classified as being at 'Poor' status. Due to the difficulty in accessing and surveying the Pymmes Brook in its lower reaches the fish populations have as yet been classified. The majority of key supporting elements for fish populations are below 'Good' status within both waterbodies.

Main pressures affecting fish populations

Morphology: The Pymmes Brook is classified as a heavily modified waterbody. Significant alterations to channel morphology throughout the length of the watercourse have been made for the purposes of flood protection, with significant stretches of culverted channel. Channel modification also impacts upon dissolved oxygen levels in the upper reaches. In the lower reaches below the confluence of the Salmons Brook the river channel is trapezoidal and concrete lined offering little habitat diversity. Numerous impounding structures throughout the watercourse inhibit natural dispersion of fish populations.

Water quality: Above the Salmons Brook confluence elevated phosphate levels; low dissolved oxygen and high ammonia combine to make water quality sub-optimal for fish populations. Within the heavily urbanised catchment diffuse inputs from numerous misconnections lead to foul water entering surface water drainage, as a result of incorrect plumbing of toilets, sinks and domestic appliances, as well as additional inputs from road runoff. Point discharges of treated and untreated sewage effluent from the water industry also impact upon water quality.

Water Framework Directive survey results 2015

Site	3-spined stickleback	Common bream	Gudgeon	Perch	Roach
Oakhill Park	100 - 999*	1	19	3	30
Arnos Park	100 - 999*				3

Table 11: Number of each species captured in a single electric fishing run at WFD monitoring sites within the Pymmes Brook upstream of Salmons Brook waterbody surveyed in 2015.

Due to the heavily urbanised nature of the surrounding catchment, with residential properties bordering much of the river channel, access to the river is limited. As such areas of park land through which the river flows offer intermittent access points.

At the furthest upstream survey site, **Oakhill Park**, limited riparian vegetation borders the narrow channelized brook, with public footpaths running the entirety of both banks. Substrate consists of a mix of silt and isolated gravel patches. Depth of water means that flow is limited. The majority of fish were captured from a small area of deeply undercut bank, with cover lacking throughout much of the site. The fish population at the site is likely to be augmented by the online lakes approximately 2km upstream, with the presence of species such as common bream unusual for a water course of this type.

Arnos Park is situated 2.5km downstream. Within this relatively short distance between the two sites a total of 13 engineered river obstructions are present. The site runs for 100m immediately downstream of a weir. Hard engineered banks line the majority of the river channel, with little noticeable flow. Fish populations present were found to be extremely limited with very few small roach and three-spined stickleback found to be present. The presence of such a large number of obstructions restricts distribution of the more varied fish community found upstream, with intermittent pollution events likely to limit the ability of fish to persist within effectively isolated sections of brook.

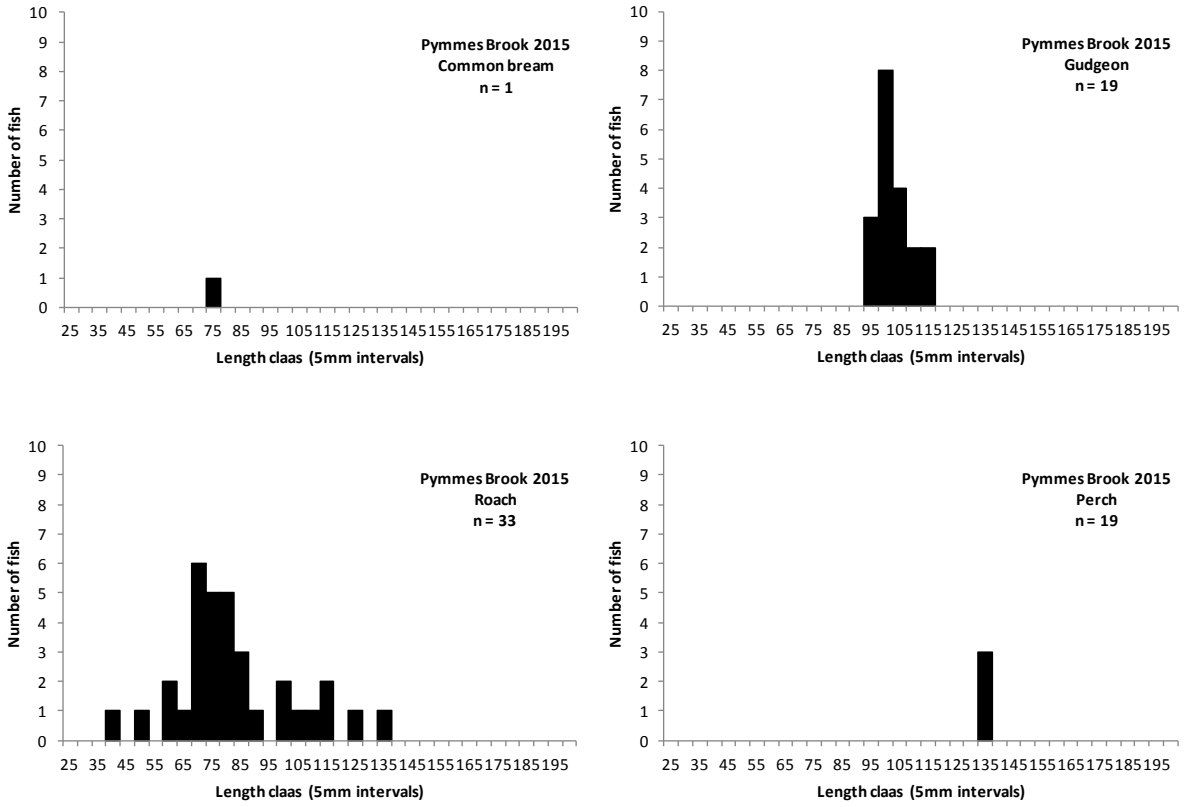

Figure 9.2: Length frequency histograms for fish species captured during 2015 surveys of the Pymmes Brook.

River Ash

Catchment overview

The River Ash is a tributary of the River Lee which rises as an intermittent stream around the village of Brent Pelham. The river runs south in a steep sided valley toward the village of Much Hadham where it begins a more south easterly course. Here it continues through a rural valley where it joins the Amwell Loop of the Lee to the south of the town of Ware.

Much of its catchment consists of arable and pastoral agriculture within its steep sided valley. The small villages in its upper and middle reaches are the only urbanised areas present. Throughout the catchment superficial geology consists predominantly of clay, silt, sand and gravels, with underlying bedrock geology of Lewes nodular and Seaford chalk formation.

Figure 10.1: The River Ash at Watersplace Farm

Water Framework Directive classifications

Waterbody	Fish	Invertebrates	Macrophytes and Phytobenthos	Ammonia	Dissolved Oxygen	Phosphate
Ash (from Meesden to confluence with Bury Green Brook)	No data	Good	No data	High	High	High
Ash (from confluence with Bury Green Brook to Lee)	Moderate	High	Good	High	High	Good

Table 12: Water Framework Directive 2015 classification for fish and some of the other key elements affecting fish within River Ash WFD waterbodies.

Of the two WFD waterbodies that encompass the River Ash at present only the waterbody Ash (from confluence with Bury Green Brook to Lee) has been classified for fish populations at 'Moderate' status. Surveys to provide fisheries classification data for the upstream waterbody, which at present has an overall waterbody classification of 'Good', are scheduled to be carried out in 2017.

Main pressures affecting fish populations

Morphology: barriers in the form of weirs created for historical land management and agricultural purposes impact upon the ability of fish, both salmonid and coarse species, to migrate within the river system. Some reparation work to mitigate for this has begun, with fish passage improvement work to the ford at Watersplace Farm having been completed.

Wild Brown Trout survey results 2015

As part of the Wild Brown Trout element of the National Fisheries Monitoring Programme two sites are surveyed biennially on the River Ash.

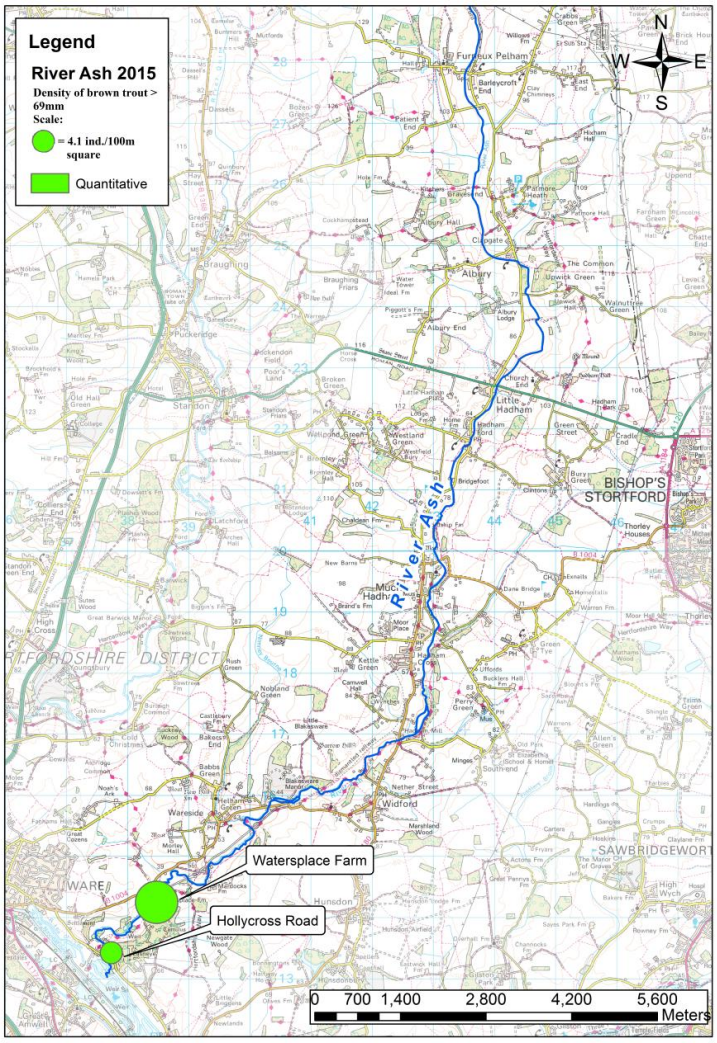

Figure 10.2: Location of River Ash monitoring sites 2015 showing comparative estimated density of brown trout >69mm.

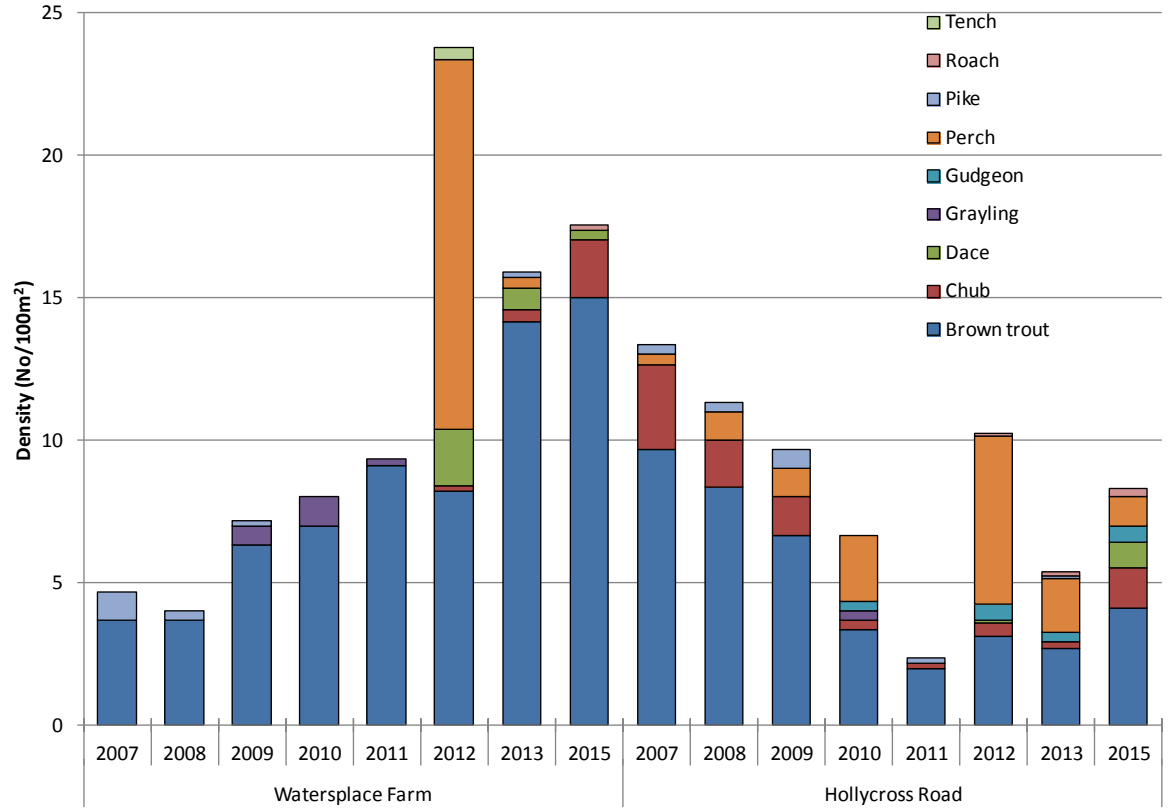

Figure 10.3: Carle and Strub density estimates for fish species >69mm at Watersplace Farm and Hollycross Road 2007 – 2015.

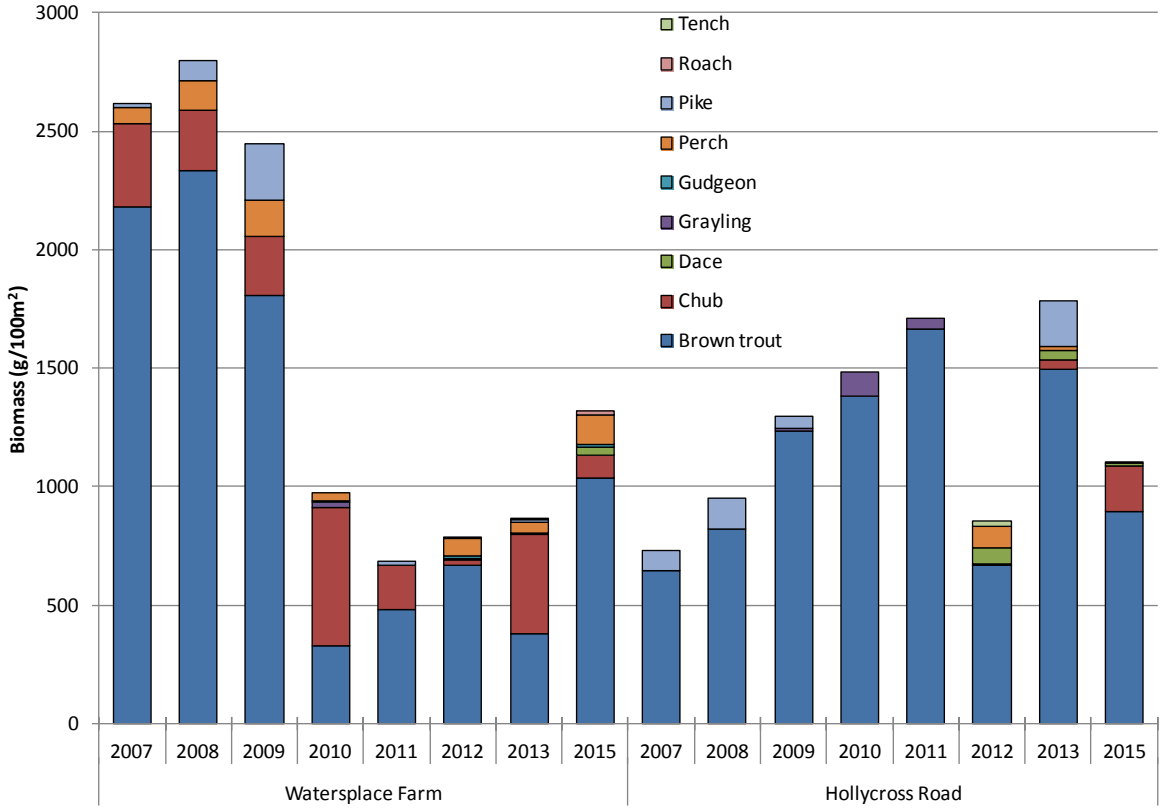

Figure 10.4: Carle and Strub biomass estimates for fish species >69mm at Watersplace Farm and Hollycross Road 2007 – 2015.

At **Watersplace Farm** our survey site runs from the ford 100m downstream to the border of the field on the right hand bank. Surrounding land use is agricultural pasture. The site is open throughout with limited riparian vegetation in the form of a few shrubs and a single willow. In stream macrophyte growth is more abundant with submberged beds of *Ranunculus* species and starwort, marginal glyceria and watercress beds which provide cover for juvenile trout and prey organisms. The non-native species Himalayan Balsam *impatiens glandulifera* has also become more established in recent years. Throughout much of the site marginal macrophytes pinch the river channel creating increased velocity of water, and subsequently clean gravels. Silt deposition is evident within areas of slack water behind macrophyte stands, and particularly at the upstream extent of the site where the channel widens and deepens to pool habitat. The sediment load is increased by cattle entering the river channel just upstream of the ford.

Habitat present is well suited to recruitment and the juvenile life stages of brown trout. Counts of redds, the distinct areas of gravel excavated by trout during spawning, previously conducted by the Environment Agency has shown this area of the Ash to be particularly well utilised by spawning trout. The 2015 survey produced the highest estimated density of brown trout at the site to date. A total of 80 brown trout were captured, with 80% of these fish being below 125mm in length. Ageing data derived from scale samples taken in previous years suggests fish of this size class are young of year and 1+ age group fish, and that brown trout recruitment may have been particularly successful over the past couple of years within this part of the Ash. Larger brown trout are not as abundant as in past years, although individuals of up to 386mm were captured from within the deeper pool area just below the ford. Biomass of the species peaked between 2007 and 2009. This coincides with the lowest densities of brown trout.

Figure 10.5: Juvenile brown trout captured at Watersplace Farm

Coarse fish species have featured more prominently in recent surveys. In 2012 perch were estimated to be the most abundant species at the site, with good numbers of small juveniles captured. High summer flows in that year may have facilitated upstream migration of coarse species from the lower reaches.

At **Hollycross Road** habitat is in contrast to that found at our upstream site. Situated above the road bridge at Hollycross Road the river channel flows through thick deciduous woodland, which borders an area of arable farm land. In 2015 the site was shifted approximately 20m upstream in comparison to previous years. This was due to the large area of pool at this point having eroded to become increasingly deep over the years, to the extent where it was no longer possible to either safely or efficiently survey this part of the river. Being further down the catchment the river channel is wider, the river slower flowing with a gravel substrate. Increased turbidity and deposition of silt is also evident Heavy shading from trees throughout the site limits instream macrophytic growth. The majority of cover is provided by riparian shrubs, grasses and trees bordering the river channel, undercut banks and tree root systems. The non native species Himalayan balsam is particularly prominent, and it was also noted that the North American Signal Crayfish *Pacifastacus leniusculus,* another non native species, is present in high densities within this part of the Ash.

Estimated density of brown trout peaked at the site in 2007, at which time the site supported a greater abundance than Watersplace Farm. In 2015 trout density was 27% of that found at Watersplace Farm. Habitat is not as well suited for successful spawning and juvenile trout as that found upstream, with greater siltation of spawning gravels, and comparatively limited instream cover.

However estimated biomass of trout at the site is very similar to that found upstream and is indicative of the fact that the majority of trout are larger adult fish, with an average length of 215mm. Previous redd counts have indicated that the area is used as spawning grounds by adult trout, though it is possible that many of the fish using the site to do so are migrating upstream from the nearby Amwell Loop of the Old River Lee, which in part is run as a trout fishery by the Amwell Magna fly fishing club. Migration of fish between these two watercourses sees a greater diversity of species feature in our surveys, with roach, perch, dace, gudgeon and chub all present in 2015.

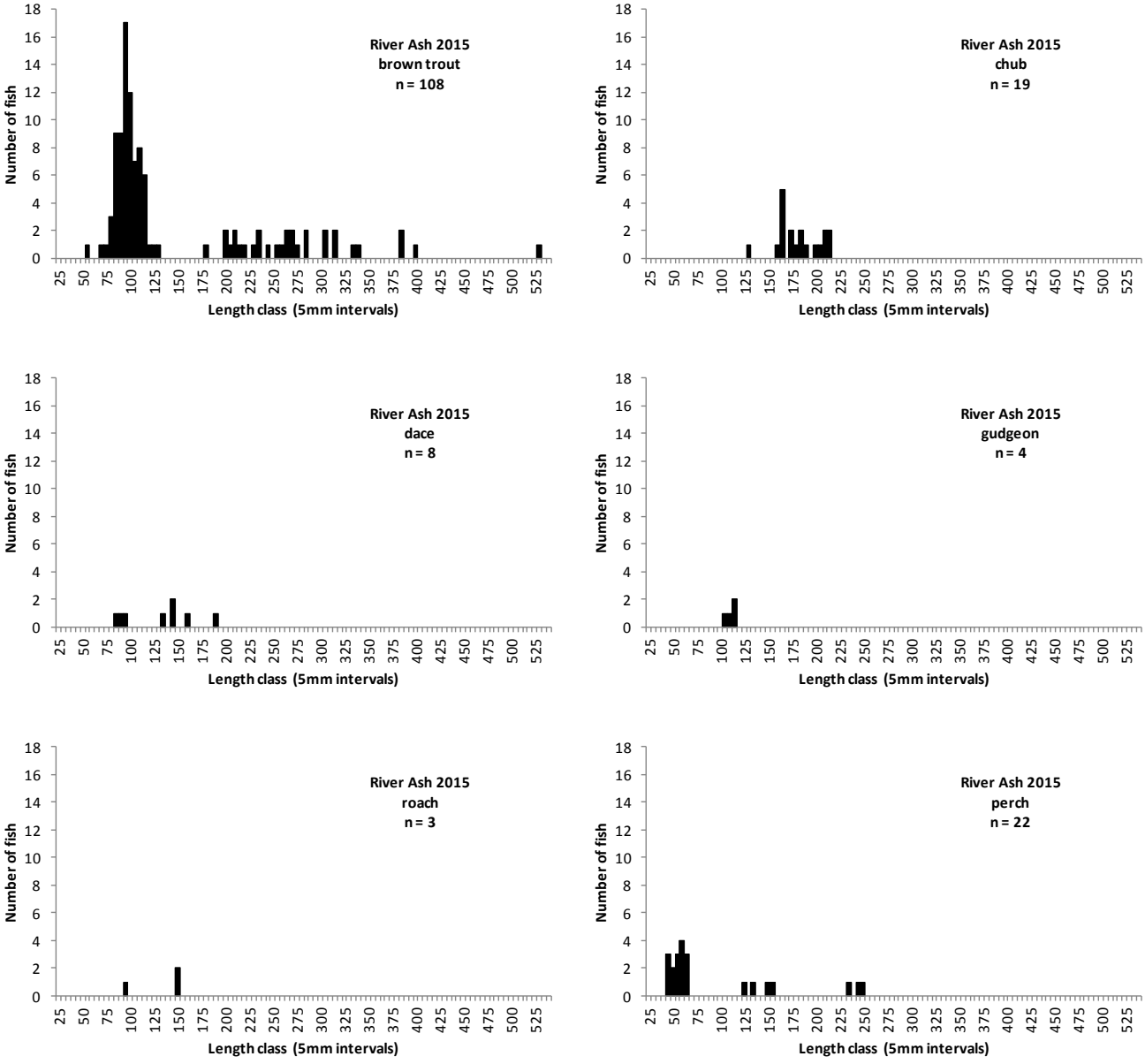

Figure 10.6: Length frequency histograms for fish species captured during the 2015 surveys of the River Ash

River Mimram

Catchment overview

The River Mimram is a chalk stream, and the most westerly of the major tributaries of the River Lee. Rising as springs to the north-west of the village of Whitwell, it flows south-easterly for some 26km through a drainage catchment of approximately 143km^2. This catchment is initially predominated by agricultural land, before flowing through the northern edge of Welwyn garden City, and onwards to join the River Lee to the west of Hertford. Where the impact of anthropogenic activity is least felt, the River Mimram provides habitat typical of many other chalk streams, with water rising from the chalk aquifer providing consistently cool water temperatures that sustain the presence of salmonid species such as brown trout and grayling. Shallow water flows briskly over overlaying gravels providing suitable spawning substrate for both brown trout and grayling alike, whilst abundant marginal water cress beds, give shelter to both juvenile fish, and fish prey organisms.

Figure 11.1: The River Mimram at Tewin Flyfishers

Water Framework Directive classifications

Waterbody	Fish	Invertebrates	Macrophytes and phytobenthos	Ammonia	Dissolved Oxygen	Phosphate
Mimram (Whitwell to Codicote Bottom)	Good	High	Good	High	High	Moderate
Mimram (Codicote Bottom to Lee)	Moderate	High	Good	High	High	Good

Table 13: Water Framework Directive 2015 classifications for fish and other key elements affecting fish within River Mimram WFD waterbodies.

Two waterbodies are classified for WFD encompassing the length of the River Mimram. Based on the 2015 classification results both waterbodies are at an overall status of 'Moderate'.

Main pressures affecting fish populations

Hydrology: Groundwater abstraction for the water industry is especially detrimental to the ecological status of the River Mimram. For fish species this manifests itself through a reduction in flow which may impact upon their ability to traverse both natural and artificial barriers, restricting upstream migration to headwater spawning grounds, especially important in order for salmonid species to complete their life cycle. Low flows also reduce flushing of fine sediments from spawning gravels and subsequently increase sedimentation, which may reduce oxygen levels within the gravels and egg survival.

Morphology: The middle to lower reaches of the River Mimram below Digswell are particularly affected by impounding structures in the form of weirs, sluices and mills. These have the effect of restricting migration of both salmonid and coarse fish species, whilst isolating discrete populations, making them more vulnerable to localised environmental perturbations. River habitat upstream of such structures may also be degraded as decreased velocity of flow and increased depth of water facilitate increased deposition of sediments, leading to gravels becoming coated.

Sediment: Significant inputs of sediment into the River Mimram adversely affect fish species through clogging or smothering of gravels, rendering them unviable as a spawning medium for species such as brown trout, and rheophilic coarse fish. In the upper reaches where the river flows through agricultural land these inputs are driven by land management practices, with significant run off from surrounding arable land into the river channel. As the river flows through conurbations there are increased inputs from urban drainage; in particular from road run off which add further to the sediment load.

Tewin investigative survey results 2015

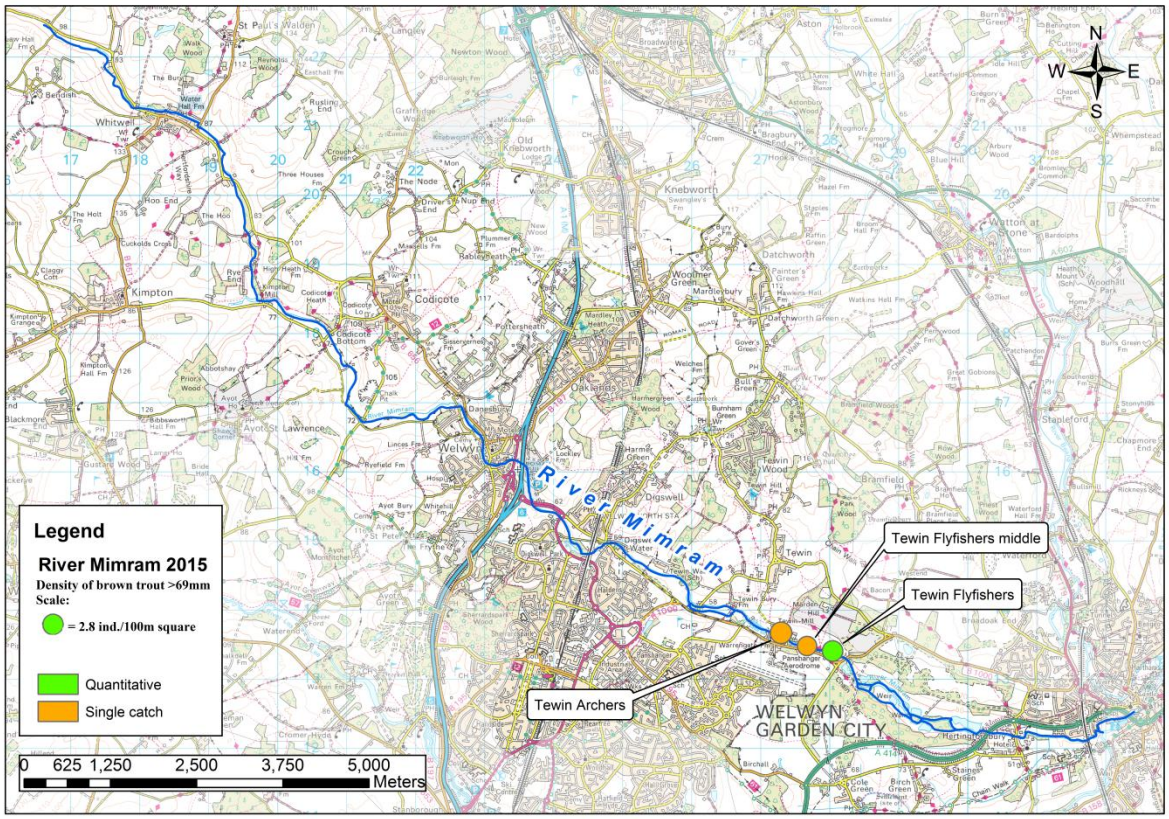

Figure 11.2: River Mimram catchment showing location and comparative density of brown trout >69mm at Tewin investigative survey sites.

In October 2015 the Environment Agency undertook a series of three investigative surveys on the River Mimram at Tewin. These surveys were in response to concerns raised by the Tewin Flyfishers syndicate over levels of brown trout recruitment within the stretch of the Mimram to which they hold fishing rights.

The **Tewin Flyfishers** site is part of our routine Wild Brown Trout monitoring programme, and is usually surveyed biennially. As this site provides a comparable temporal data set it was surveyed again in 2015. In addition two new sites offering contrasting habitat were surveyed as single catches in order to gain a greater understanding of brown trout population structure, and to highlight potential life stage bottlenecks within this part of the Mimram. Habitat within this site is well suited to juveniles. There is an abundance of marginal macrophytic growth, primarily watercress *Nasturtium officinale*, and submerged in channel macrophyte beds which were particularly dense in 2015. Shallow swiftly flowing water predominates throughout the site with some areas of deeper water, most noticeable being two pools beneath weirs at the upstream and downstream extents.

Quantitative survey data from our routine monitoring site at Tewin Flyfishers does provide some evidence to suggest that numbers of juvenile brown trout present within the section of river have fallen in recent years (Figure 11.3). This coincides with a significant increase in the number of juvenile grayling we are capturing. An Environment Agency stocking of 500 grayling into this part of the Mimram in August 2012 may have helped the species to become established as a viable breeding population. Since this time they have been more abundant

than trout, with successively strong cohorts of young of year fish having featured in our surveys.

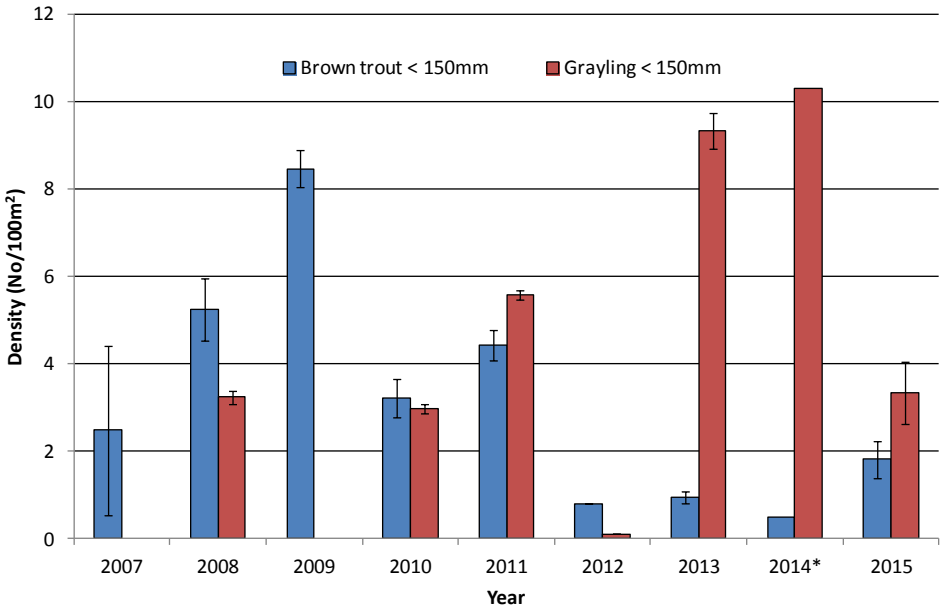

Figure 11.3: Carle and strub density estimates (+/- 95% Confidence Limits) for juvenile brown trout and grayling <150mm at Tewin Flyfishers 2007 – 2015. *denotes data is based on a single catch.

The second site surveyed, **Tewin flyfishers middle**, is situated immediately above the footbridge upstream of our routine monitoring site. Here a single catch was conducted encompassing a 200m length of river. Habitat here differs from that found downstream. The river is generally deeper, and in the slower flowing sections there is a resultant increase in sedimentation. Shading from riparian trees, especially towards the upstream extent where the river flows through a dense copse, limits instream macrophyte growth. The results of this survey are not quantitative, being based on a single catch, and the true fish population present is likely to be under-represented in the results. However it is clear that this site supports good numbers of grayling with 202 captured. Increased depth of water seems to provide habitat preferred by larger individuals, with grayling of up to 404mm in length present. Again juveniles were found throughout this stretch. Brown trout were not found to be as abundant, with smaller juveniles in particular not featuring as prominently in the catch.

The **Tewin Archers** site is the furthest upstream of the three. Here habitat is more diverse than through the middle section, with areas of light and shade created by the intermittent nature of the tree line bordering the river channel. Shallow riffles, runs and glides give way to deeper pool areas. The river channel is narrower with greater velocity of water meaning clean gravels are more prevalent, whilst increased light reaching the river channel has allowed beds of *ranunculus* to become established. Again although results are not quantitative, results (Figure 11.4) suggest this site may support the highest densities of brown trout, with numbers of brown trout and grayling more even than at either of the other sites.

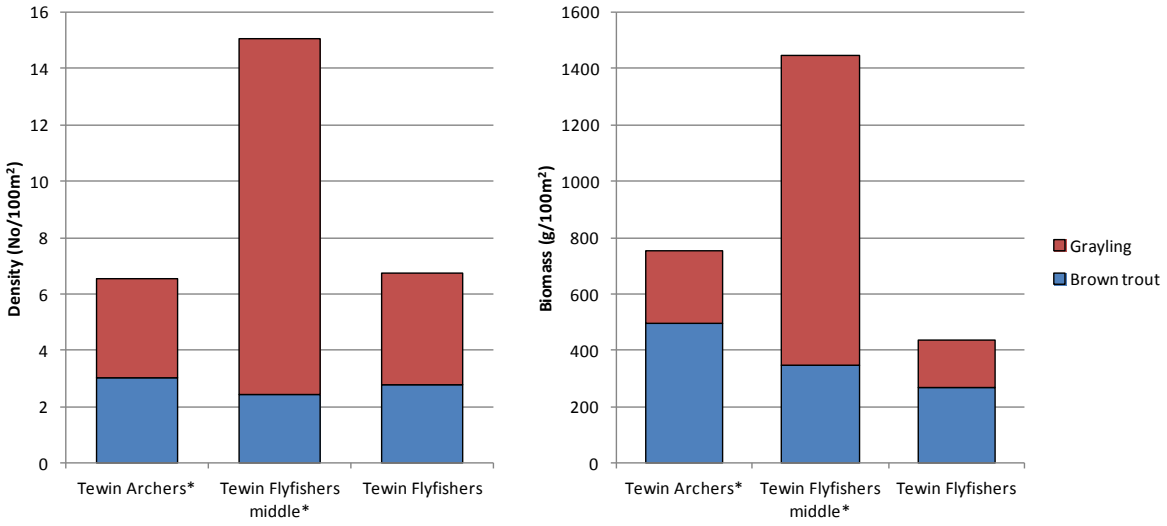

Figure 11.4: Comparative density and biomass of brown trout and grayling at Tewin Flyfishers investigative survey sites 2015. * denotes results based on a single catch and not quantitative.

The three 2015 surveys recorded a total of 101 brown trout from a combined stretch of approximately 510m of river. What is perhaps the most striking aspect of this survey was the extent to which grayling have become established. Their numbers have fluctuated significantly over the time period of our surveys at Tewin Flyfishers, and having been absent in 2007, they have been found in higher densities than trout in the last three years of surveys. In the middle site in particular they are flourishing with a range of size classes evident, and in total featured more than three times as heavily as trout in the catch.

Length frequency histograms for trout and grayling are shown in Figures 11.6 and 11.7 respectively. These give detail for each site and are also combined to give an overall picture of the population structure within this part of the River Mimram. Length frequency patterns for the fishery as a whole follow those that would be expected within a healthy brown trout population, with juveniles well represented, and progressively decreasing numbers of larger size classes.

Figure 11.5: Brown trout captured from the Archers section at Tewin.

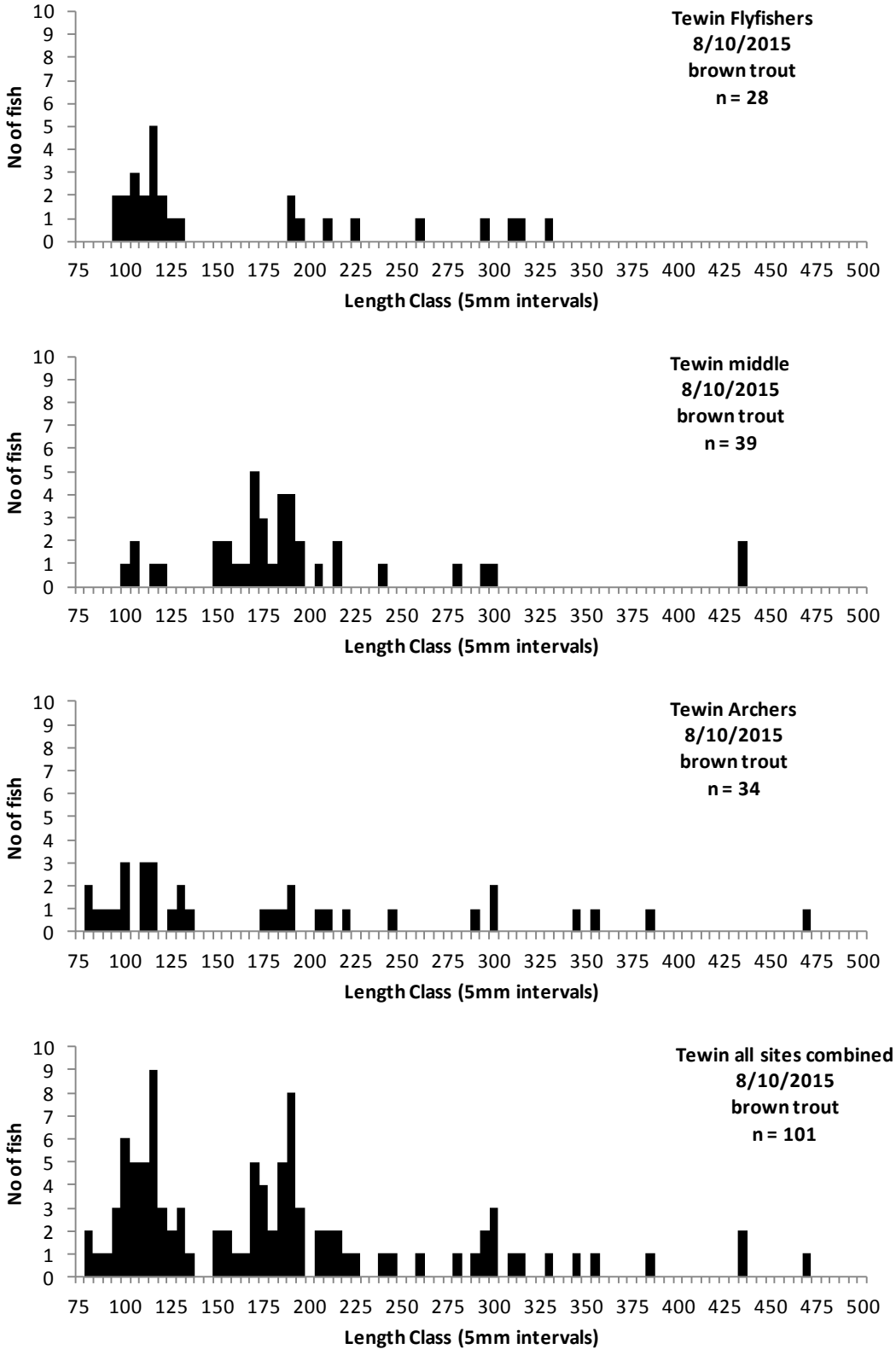

Figure 11.6: Length frequency histograms for brown trout captured during Tewin investigative surveys 2015.

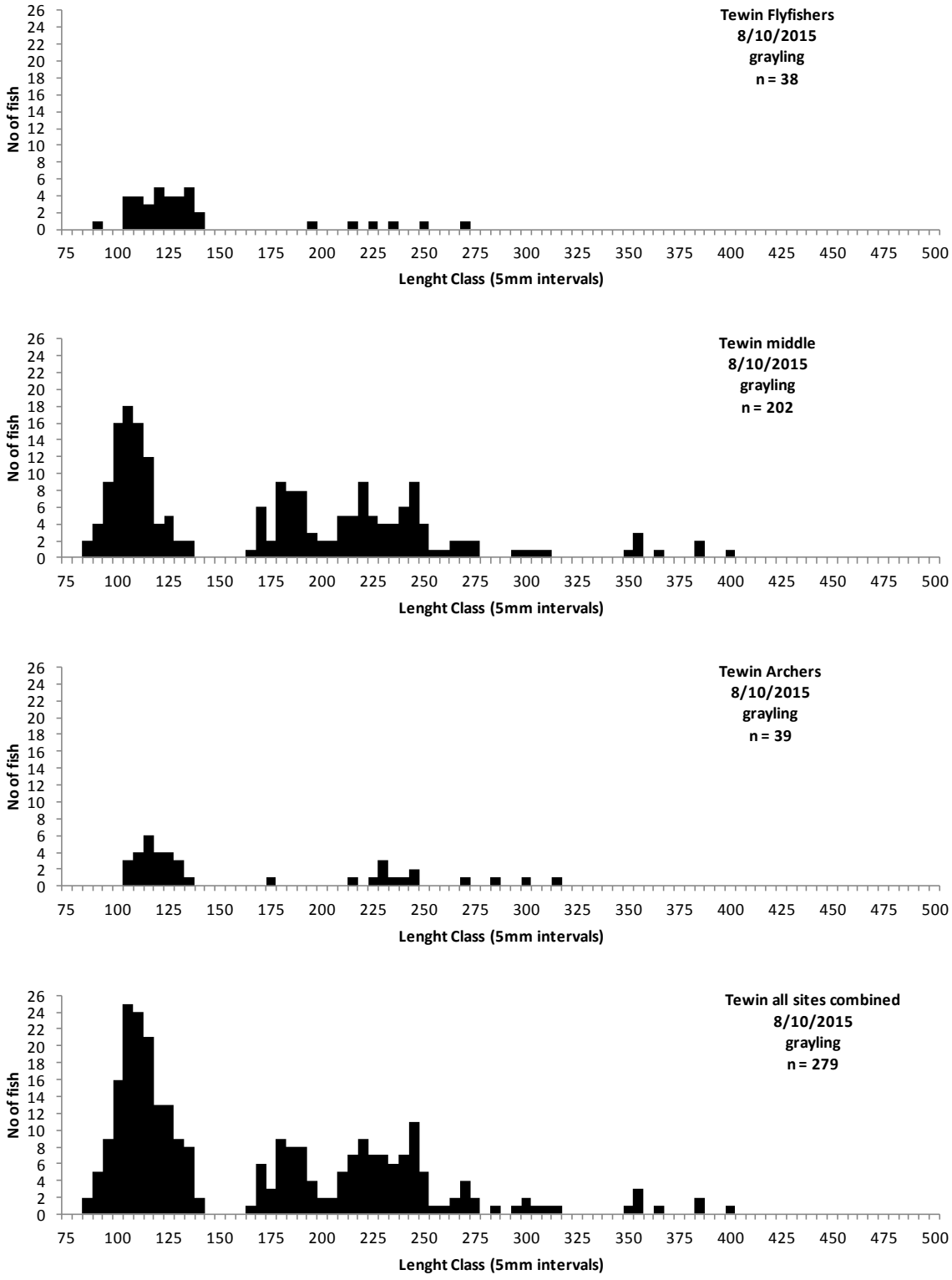

Figure 11.7: Length frequency histograms for grayling captured during Tewin investigative surveys 2015.

River Stort

Catchment overview

The River Stort rises near Langley in Essex and flows south via Bishops Stortford to Harlow. From here the course of the river veers south-westerly, past Roydon to join the River Lee at Fieldes Weir near Hoddesdon in Hertfordshire. The total distance from source to confluence is approximately 46km, draining a catchment of 278km^2. Bedrock geology is chalk in the upper reaches overlain with alluvium gravels, whilst below Sawbridgeworth London clay overlays this chalk, before bedrock geology shifts to clays below Harlow, overlain with gravels. The three main tributaries of the Stort are the Great Hallingbury, Pincey and Canons Brooks

In the upper reaches between Langley and Stanstead Mountfitchet the river can run dry during the summer. Springs at Hazel End supplement the flow and the river remains flowing year round downstream of this point. Below bishops Stortford the river becomes formalised in the shape of a navigation channel which runs to the River Lee. Distinct side loops, remnants of the old river channel, diverge from and rejoin the navigational channel, the flow within these is regulated by fixed crest weirs.

Water Framework Directive classifications

Waterbody	Fish	Invertebrates	Macrophytes and phytobenthos	Ammonia	Dissolved Oxygen	Phosphate
Stort and Bourne Brook	Not assessed	Good	Good	High	Good	Poor
Stort and Navigation, Bishops Stortford to Harlow	High	Good	Not assessed	High	High	Poor
Stort and Navigation, Harlow to Lee	Not assessed	Moderate	Not assessed	High	High	Poor

Table 14: Water Framework Directive 2015 classifications for fish and other key elements affecting fish within River Stort WFD waterbodies.

At present only the waterbody Stort and Navigation, Bishops Stortford to Harlow is classified for the status of its fish populations and is at ‘High’ status. Further surveys to provide data for the classification of the waterbody Stort and Navigation, harlow to Lee are scheduled to be completed in 2017.

Main pressures affecting fish populations

Phosphate: The limiting nutrient to photosynthetic productivity in freshwater. The River Stort is currently classified as being at ‘Poor’ status for phosphate under the Water Framework Directive. The water industry contributes significantly to the phosphate load of the river with discharges of treated sewage effluent from major stw’s at Stansted Mountfitchet and Bishops Stortford, as well as at Little Hallingbury on the Storts tributary the Great Hallingbury Brook. Unnaturally high phosphate levels drive the process of eutrophication. This may affect fish populations present within the Stort river system by altering the plant communities present and promoting both algal blooms which subsequently alter physiochemical water quality, and

thickening the algal bio-film coating gravels. Excessive macrophyte growth on side loops as a result of increased phosphate may also narrow the river channel.

Morphology: Below Bishops Stortford the river channel has been canalised for navigation purposes and is classed as a heavily modified waterbody. Remnants of the old river channel remain as side loops, although the majority of the river is now significantly altered from its natural state, with impounding structures in the form of locks on the navigation, and fixed crest weirs regulating side loops.

National Fisheries Monitoring Programme results 2015

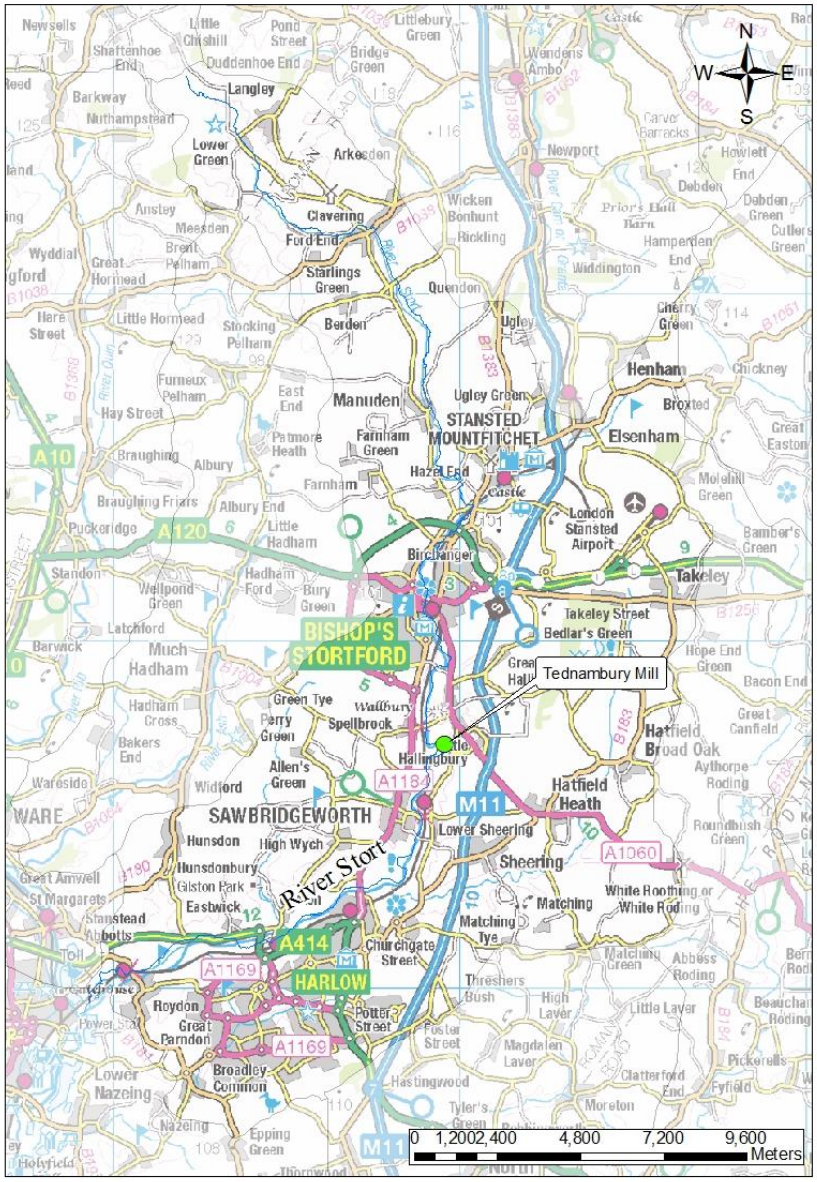

Figure 12.1: Location of Tednambury Mill survey site on the River Stort

A single site is surveyed annually for NFMP purposes on the River Stort, this being on a side loop of old river channel at Tednambury Mill.

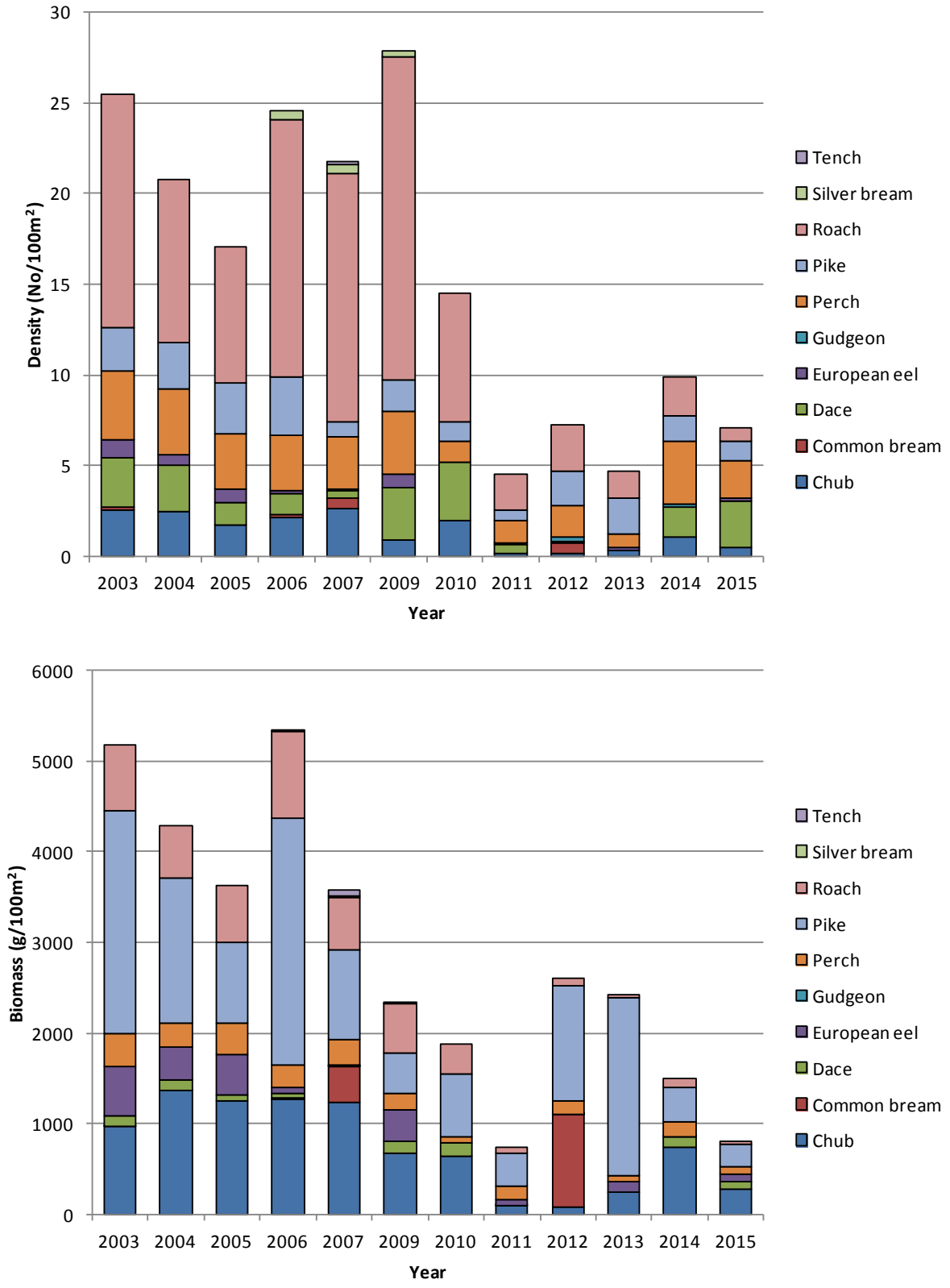

Figure 12.2: Carle and Strub estimates of density and biomass of fish species >99mm at Tednambury Mill 2003 – 2015.

Our site at **Tednambury Mill** is situated on the mill bypass channel that diverges via a weir from a side loop of the old river channel, which then flows for approximately 450m before rejoining the main loop. The main loop itself diverges from the Stort navigation, and flows for approximately 850m before rejoining. The watercourse upstream of the old mill is now used as a marina.

Abundant and diverse macrophyte growth is found throughout the entirety of the site, with dense *Sparganium* and *Schoenoplectus* beds narrowing the channel and increasing velocity of water, and submerged beds of *Nuphar lutea* and *Apium*. The effects of high phosphate inputs into the watercourse are borne out by the density of these aquatic plants. The downstream extent of the site provides greater depth of water and is more heavily shaded. These two factors mean that macrophyte growth is lessened, and the channel is not as encroached as through the middle and downstream sections.

These macrophytes provide cover for fish species across a variety of life stages, and also ideal spawning substrate for the species such as roach and perch found in this part of the Stort. Temporal comparison of the data collected over the course of our surveys suggests that fish density has fallen quite considerably since 2010. Most noticeable is the collapse in roach >99mm density post 2010, with the species regularly contributing the greatest proportion to overall density prior to this. However length frequency histograms (Figure 12.3) give an indication as to the sites suitability as nursery grounds for juvenile roach, with the majority captured being between 55mm – 65mm. This is similar to the results of the 2014 survey when good numbers of juvenile roach of this size class were also captured. Their absence as a distinct size class from this year's survey may indicate that roach seek habitat found outside of the survey site after this life stage. Macrophyte growth has become progressively dense with increased encroachment over the years, and the depth of water is not as great as initially found. This may be one reason for mature roach to seek out other areas of the river system.

Dace were estimated to be the most abundant species >99mm at the site for the first time in 2015, followed by perch.

Estimated biomass in 2015 was the second lowest to date. In most years pike and chub have been the highest contributing species to biomass. Although chub were the highest contributing species to biomass in 2015, as with roach density this has fallen since 2010.

The bypass channels connection to the section of loop impounded behind the mill house, where water is deep and slow flowing, means that occasionally limnophilic species such as tench and common bream have featured in our surveys.

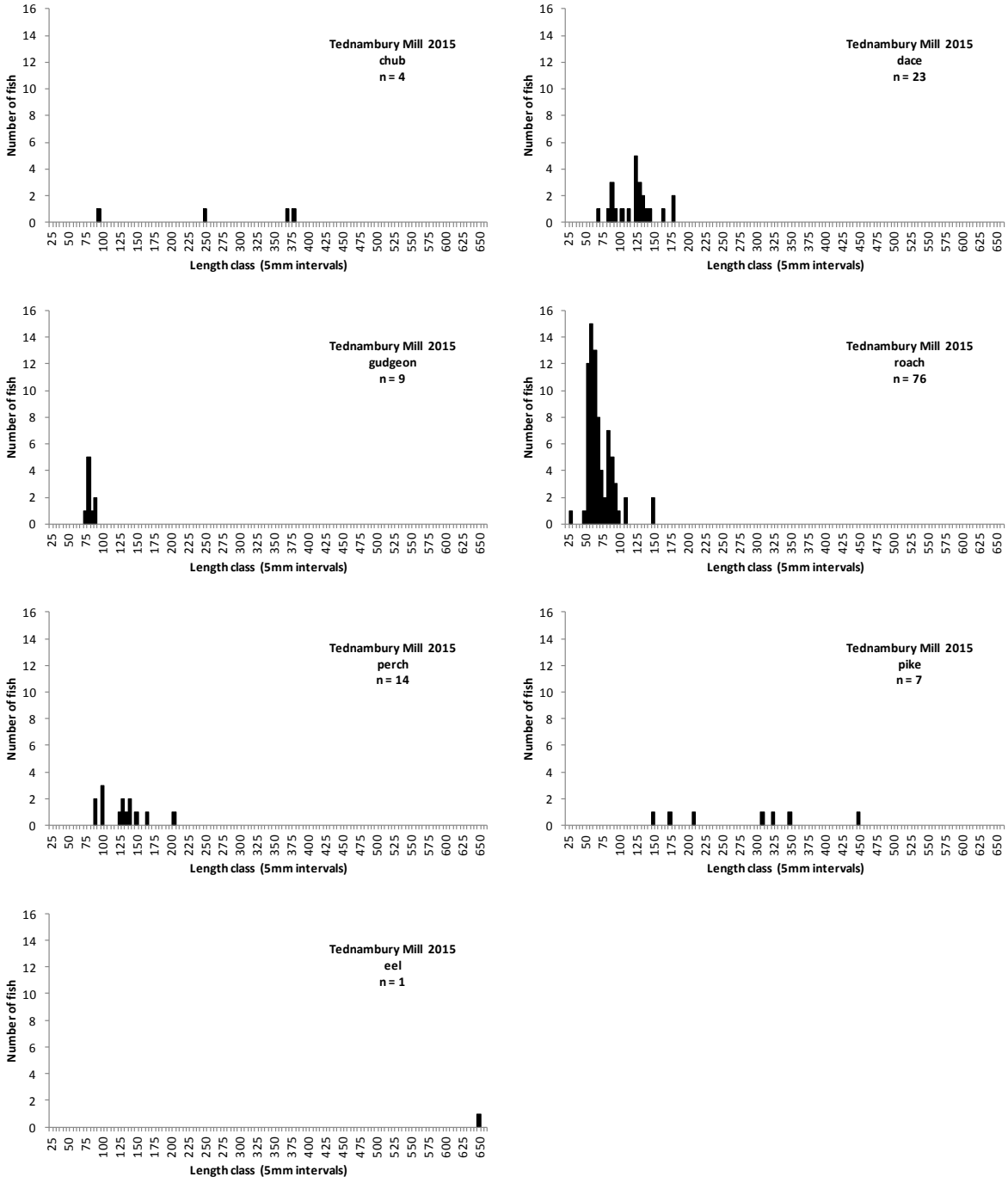

Figure 12.3: Length frequency histograms for fish species captured during the 2015 survey of Tednambury Mill.

River Roding

Catchment overview

Rising at Molehill Green to the north west of the conurbation of Dunmow, east of Stanstead airport, the River Roding winds its way south, south-westerly through the county of Essex. In the upper to middle reaches of the catchment as the river passes the villages of Fyfield, High Ongar and Abridge, surrounding land use consists almost entirely of agricultural land.

Shortly downstream of Abridge the river flows beneath and then parallel to the M11 motorway. As the river passes through Loughton, Chigwell and Woodford Green the catchment becomes increasingly urbanised. At South Woodford the course of the River Roding follows that of the North Circular road, flowing onward through Redbridge, Ilford and Loxford, before finally becoming the Barking Creek, shortly before its confluence with the River Thames at Barking. By this point the course of the river has covered approximately 74km, draining a catchment of 384km^2.

Bedrock geology throughout the catchment consists of clays. This in tandem with surrounding land management practices, means the hydrological regime of the River Roding is particularly 'flashy' (river levels and discharge respond quickly to rainfall events) in comparison with many other rivers within the Hertfordshire and North London area.

Figure 13.1: The River Roding clockwise from top left, at High Ongar, Crowther Nurseries, Ilford Golf Course and Abridge Village Hall.

Water Framework Directive classifications

Waterbody	Fish	Invertebrates	Macrophytes and phytobenthos	Ammonia	Dissolved Oxygen	Phosphate
Upper Roding (to Norton ditch)	Moderate	Good	Poor	High	High	Moderate
Lower Roding (Cripsey Brook to Loughton)	Good	Good	Good	High	Good	Poor
Lower Roding (Loughton to Thames)	Not assessed	Moderate	Moderate	Poor	Bad	Poor

Table 15: Water Framework Directive 2015 classifications for fish and other key elements affecting fish within River Roding WFD waterbodies.

Main pressures affecting fish populations

Morphology: In the upper reaches the river channel has been significantly altered for flood protection and sediment management purposes, with the river channel re-sectioned and dredged making it over wide, artificially deep and lacking hydrological energy which allows settlement of fine particulate matter. Limited connectivity with the flood plain, and a lack of marginal refuge leaves fish populations vulnerable to high flow events within this particularly 'flashy' river system. Twelve weirs are dotted throughout the length of the Roding; along with the remnants of Waples Mill upstream of Fyfield these restrict migration of fish species.

Sediment: Agricultural land use practices in the middle to upper reaches produce significant inputs of sediment which enter the river channel through poaching of banks by cattle and run off from arable farm land. In the urbanised lower reaches diffuse inputs from housing and road drainage, and sewage discharge increase the sediment load.

Invasive non-native species: The American signal crayfish *Pacifastacus leniusculus* is widespread throughout the Roding catchment. The full impact of this species is as yet not fully understood, although they are known to increase erosion of river banks through burrowing and consequently the sediment load. They are opportunistic feeders, predating on aquatic invertebrates, including other signal crayfish, plant material, and potentially fish eggs and juvenile fish.

Fisheries survey results 2015

Four surveys were conducted as part of the NFMP on the River Roding in 2015. A further survey at Abridge Village Hall was carried out for WFD classification purposes.

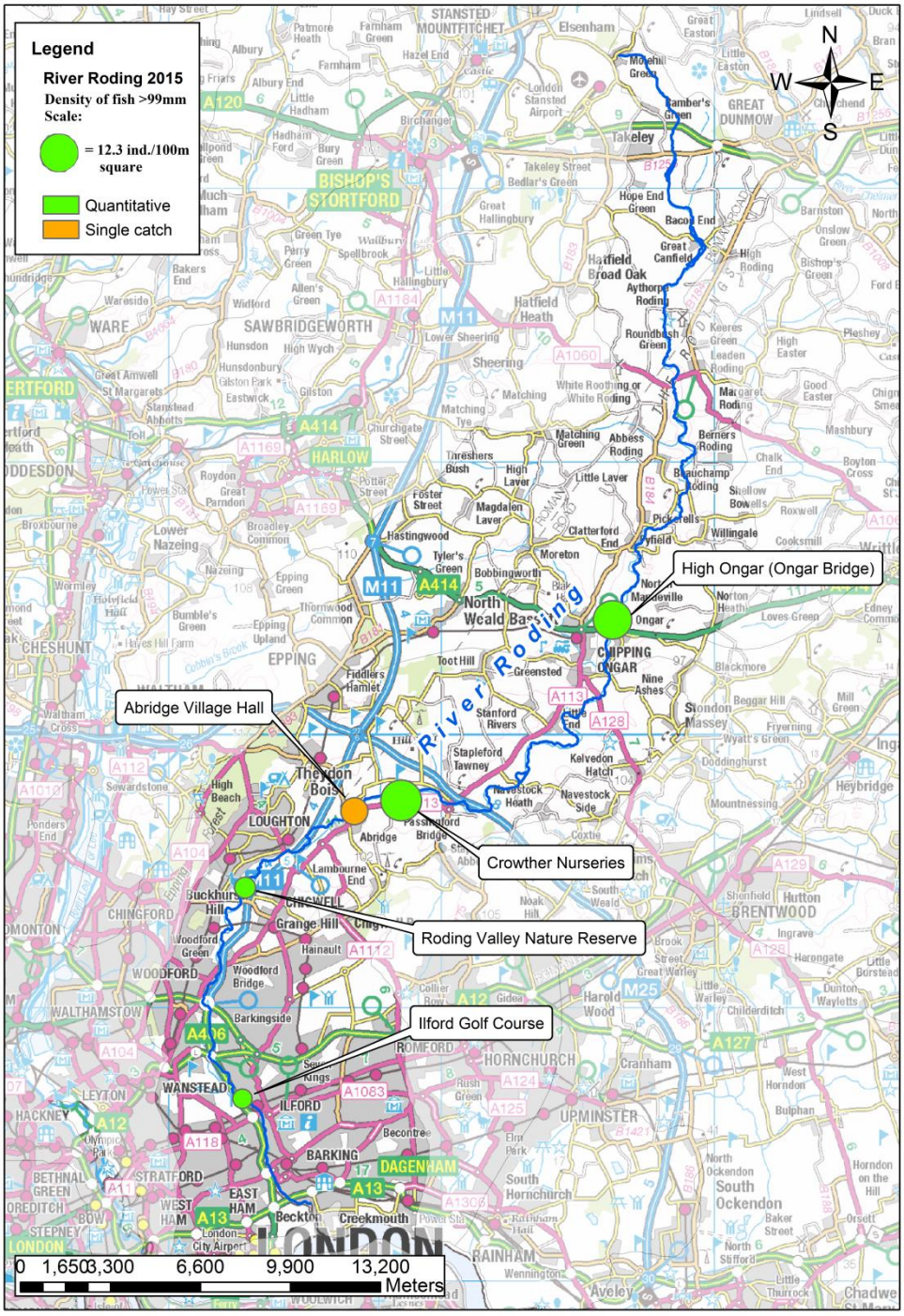

Figure 13.2: River Roding catchment showing location and comparative densities of fish >99mm at Environment Agency fisheries monitoring sites 2015.

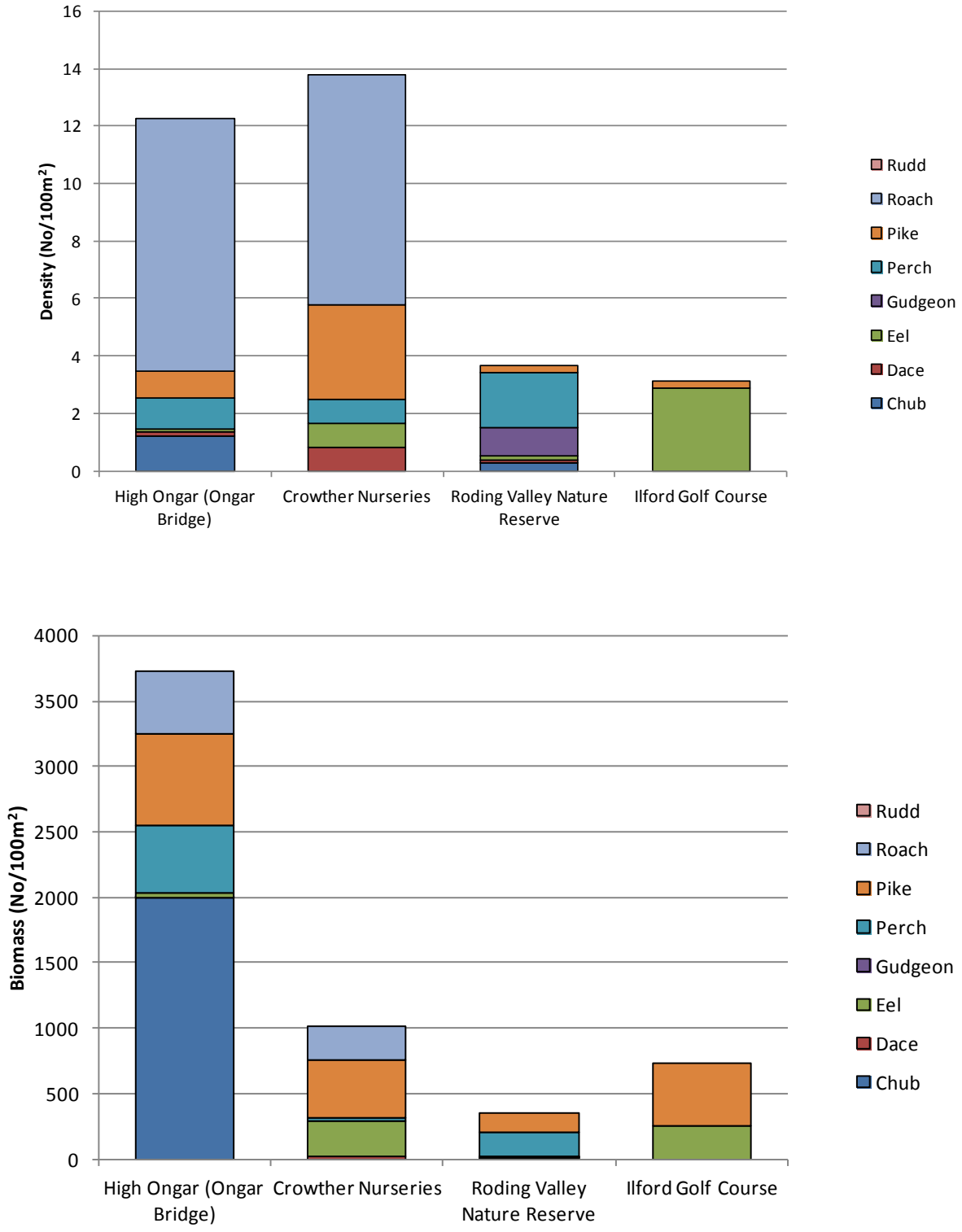

Figure 13.3: Carle and Strub estimates of density and biomass of fish species >99mm at River Roding NFMP sites 2015.

Our survey site on the River Roding at **High Ongar** is set within a landscape of arable farm land situated to the north of the A414. The site runs from below an area of woodland for approximately 100m downstream to an Environment Agency hydrometric gauging weir. The river channel here is deep set, providing little connectivity with the flood plain, and is lined by dense marginal beds of *Sparganium erectum* throughout almost its entirety. A narrow riparian band of shrubs and grasses borders the river channel and provides little shade. The effects of historic channel realignment and the impoundment immediately downstream, means that depth of water is greater than would naturally be expected and limits light reaching the river bed and promoting submerged macrophytic growth. Morphological alteration also means the hydrological energy of the river is reduced under normal flow conditions, with little flow evident. Despite the narrow channel, depth of water necessitates that the site be surveyed by boat.

When last surveyed in 2012 density and biomass of fish species >99mm at the site was estimated to be very low at 0.54 ind./100m^2, with only 16 fish captured in total. In 2015 density was estimated to be far higher at 12.3 ind/100m^2. Roach were the most abundant species accounting for an estimated 72% of overall fish density. This part of the Roding provides good habitat for roach recruitment and juvenile lifestages, with abundant marginal stands of *Sparganium* providing cover for small fish. The slow flowing nature of the river also suits this limnophilic species. When weather conditions are favourable roach populations are likely to thrive. However the combination of morphological alteration to the river channel, resultant limited flood plain connectivity and impermeable clay bedrock which predominates throughout the catchment is likely to severely impact the resilience of fish populations to 'flashy' high flow events, leading to a 'boom and bust' scenario within the roach population. This may in part explain the low density of roach in 2012 when the survey was conducted during a particularly wet summer, and the higher densities of fish in 2015, which was preceded by a particularly dry winter and summer. As results only detail fish >99mm the large number of juvenile roach captured at the site in 2015 are not fully represented in the results shown in Figure 13.3, with 76% of the 120 roach captured being below this size, although these are apparent within length frequency histograms (Figure 13.8, page 97).

Figure 13.4: Perch (left) and chub (right) captured during the 2015 survey at High Ongar

The site supports some impressive large perch and chub. Both species, but in particular perch, are likely to be attracted by the large number of juvenile roach present at the site which provide ideal prey. Large chub have featured sporadically at the site, but in 2015 a total of nine chub were captured with a mean length of 470mm, with the species the most

significant contributors to estimated biomass at the site. Situated in the mid to upper reaches of the catchment, juvenile rheophilic species such as chub and dace would normally be expected to be present. Excessive sedimentation of the substrate within this part of the Roding may limit spawning success of these species, which may seek out more suitable areas of habitat outside of the immediate vicinity of our site.

Downstream the river flows on through arable farm land to **Crowther Nurseries.** Here vegetation heavily encroaches on the river channel, with clear areas of deeper pool interspersed along its length. Under normal flow the river is almost static, overly deep and lacking sufficient gradient. Trees bordering the river provide areas of shade, and additional cover for fish species.

The site produced the highest estimated density of fish >99mm of any of those surveyed on the Roding in 2015, and the highest at the site since 2003. As at High Ongar, roach were the most abundant species with their density having increased from just 0.15 ind/100m^2 when last surveyed in 2013, to 8.8 ind./100m^2 in 2015. Fish populations are likely to face many of the same issues faced at High Ongar, namely lack of both connectivity with the flood plain and refuge during high flow events, and this increase in roach abundance may have been facilitated by the less extreme flows experienced over the preceding summer and winter of 2014/15.

Rheophilic species form a small part of the fish community present, with low numbers of dace captured, and chub absent from the 2015 survey. Although in past survey years these species have been found in higher densities, hydro-morphological characteristics within this part of the Roding are likely to limit populations of these species, with limited hydrological energy during normal flow conditions; subsequent increased deposition of silt makes much of the substrate unviable as a spawning medium.

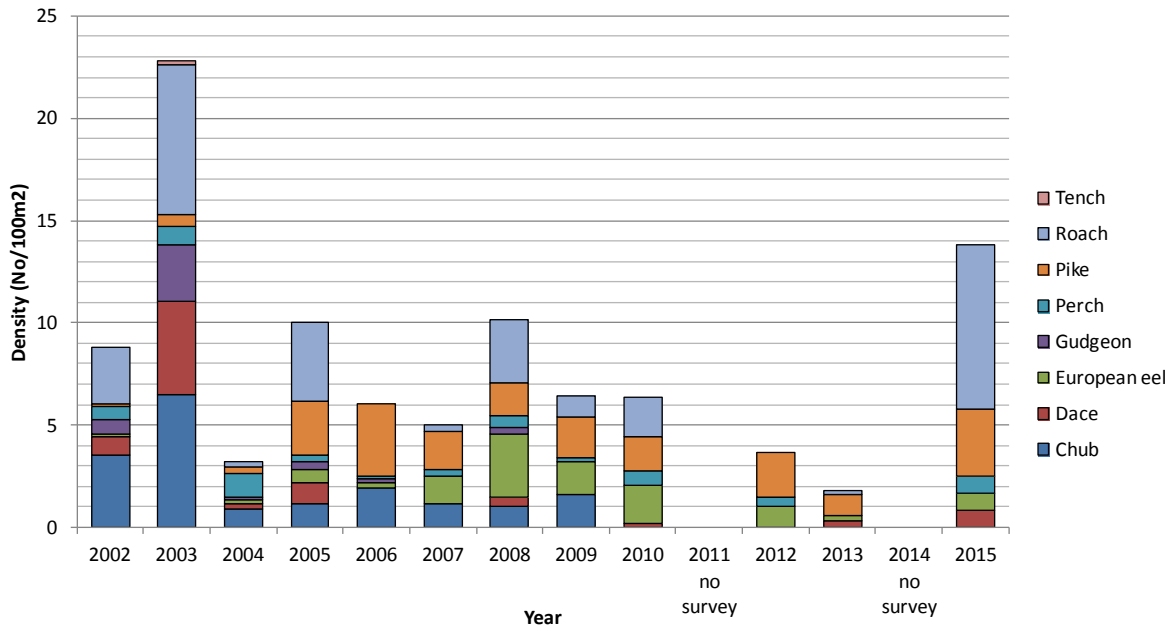

Figure 13.5: Carle and Stub density estimates for fish species >99mm at Crowther Nurseries 2002 – 2015

The river widens with less encroachment from marginal vegetation as it flows through **Roding Valley Nature Reserve** to the south of Loughton. The site has one distinct deeper pool area, with cleaner gravels towards the downstream extent of the site where the channel narrows and flows increase. *Sparganium erectum* beds line the banks, with filamentous algae noticeable in patches covering the substrate. From the middle of the site to the upstream extent overhanging trees heavily shade the river channel.

Perch were estimated to be the most abundant species, followed by gudgeon. The presence of both of these species has been intermittent, with perch absent from the previous survey in 2013, and gudgeon last captured in 2009.

The prevalence of chub has decreased in recent years. Chub contributed heavily to the density and biomass at the site in 2002 and 2003, with a noticeable decline in their numbers post 2006. Estimated eel density was also the lowest recorded to date at the site.

The furthest downstream of our sites, the Roding at **Ilford Golf Course**, flows parallel to the North Circular road. By this point the river is set within a heavily urbanised catchment, its ecological quality further impacted upon by increased diffuse pollution from urban drainage and road runoff, as well as sewerage misconnections from residential properties. There is limited macrophyte growth throughout the site, with filamentous algae present, and a predominantly silt covered substrate. The river bed is also strewn with debris. Situated approximately 3.8km upstream of the River Roding becoming the Barking Creek, and a further 2km from its confluence with the River Thames, the river within our survey site experiences a tidal influence.

As a consequence estuarine species may migrate into this part of the Roding, and when last surveyed in 2013 juvenile flounder were captured in good numbers. In most years eel are the most abundant species at the site, and this was again the case in 2015. Only pike and eel were present >99mm, juvenile roach and a single juvenile chub were also captured , with three-spined stickleback, minnow and stone loach also present.

Temporal comparison of the mean densities of some of the more prominent species present within the River Roding (Figure 13.6) suggests that density of the rheophilic species, chub and dace has fallen since 2003. Conversely the density of roach >99mm was the highest yet in 2015. Length frequency histograms (Figure 13.8) also bear out the fact that limnophilic species dominate the fish assemblage present, and indicate that strong recruitment, particularly within the roach population, is occurring. This is primarily at High Ongar and Crowther Nurseries where abundant macrophyte growth and minimal flow provide ideal roach spawning and nursery grounds. Data from previous years suggests that recruitment at these sites is not consistently strong, and that strong juvenile year classes do not always translate into increased abundance of adult fish at these sites. In comparison chub and dace numbers were low, with few juveniles captured.

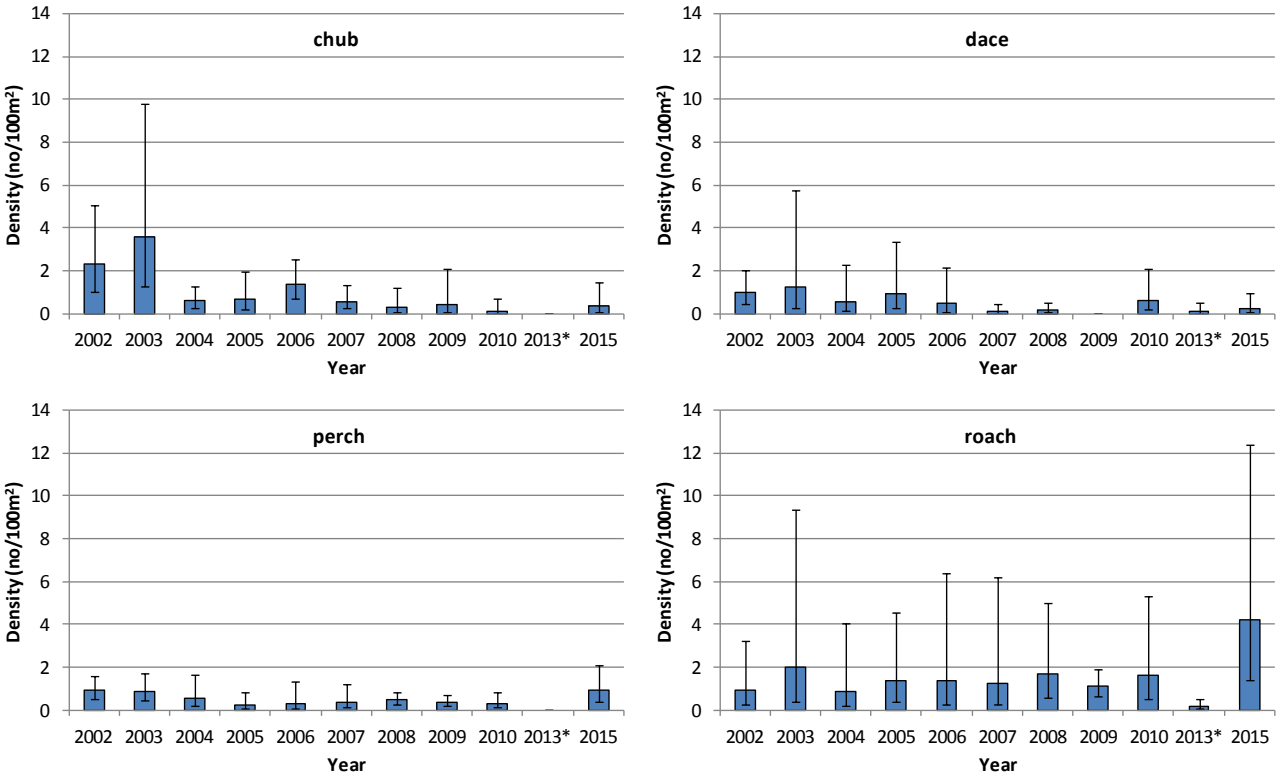

Figure 13.6: Mean estimated density of prominent fish species >99mm (+/- 95% Confidence Intervals) for the River Roding 2002 - 2015 based on data from High Ongar, Crowther Nurseries, Roding Valley Nature Reserve and Ilford Golf Course combined. (*denotes High Ongar survey not completed in this year)

Site	Chub	Eel	Pike	Roach	Bullhead	Minnow	Stone loach	Three-spined stickleback
Abridge Village Hall	1	35	6	1	122	30	5	1

Table 16: Number of each species captured in a single electric fishing run at Abridge Village Hall WFD monitoring site within the Roding (Cripsey Brook to Loughton) waterbody 2015.

This was the first time the Roding at **Abridge Village Hall** has been surveyed in order to provide fish classification data for the waterbody Lower Roding (Cripsey Brook to Loughton). Much of this section of the river is densely vegetated, both instream and bankside, and is symptomatic of the effects of nutrient enrichment through diffuse inputs of phosphate, primarily from agricultural runoff during high rainfall events and sewage effluent, with the waterbody failing for phosphate under WFD. During the summer months macrophyte growth chokes the river channel to such an extent that surveying the river becomes almost impossible. For this reason the site was surveyed in mid April 2015 before vegetation had become established.

Substrate throughout the site is predominantly covered in fine sediments, with few areas of clean gravel, with the sediment load likely to be increased within the system by agricultural runoff. The level of sedimentation is more apparent during the summer months when the dominant macrophyte species, *Sparganium erectum* commonly known as branched bur reed, and *Schoenoplectus lacustris,* common club rush, emergent species commonly found in silty substrates, form dense beds that in places completely cover the river channel. At the time of surveying the river had noticeable flow, although under normal summer flow conditions, as in much of the Roding, flow is almost non-existent due to the unnatural channel form and the effect of dense macrophyte stands holding back water.

Figure 13.7: Eel captured during the 2015 survey of the Roding at Abridge Village Hall

The 2015 survey results suggest that eel are the dominant fish species at the site with 35 captured within a length of approximately 100m of river. The abundance and diversity of other fish species was relatively low, and as with other sites surveyed on the Roding in 2015 rheophilic species in particular were not found in the numbers expected. Lack of suitable spawning substrate may be a limiting factor for rheophiles within this part of the Roding, with a lack of areas of clean gravel substrate. The low numbers of fish other than eel, may also reflect how difficult persisting within a river system that experiences such extremes of hydraulic conditions as the Roding is for many species. The river is particularly 'flashy', responding rapidly to high rainfall events, due to a combination of geology and surrounding land use. Historical channel realignment means that this water moves quickly through the river system, and has degraded habitat for fish in times of high flow, through reduction of flood plain connectivity, and availability of refuge areas providing slack water.

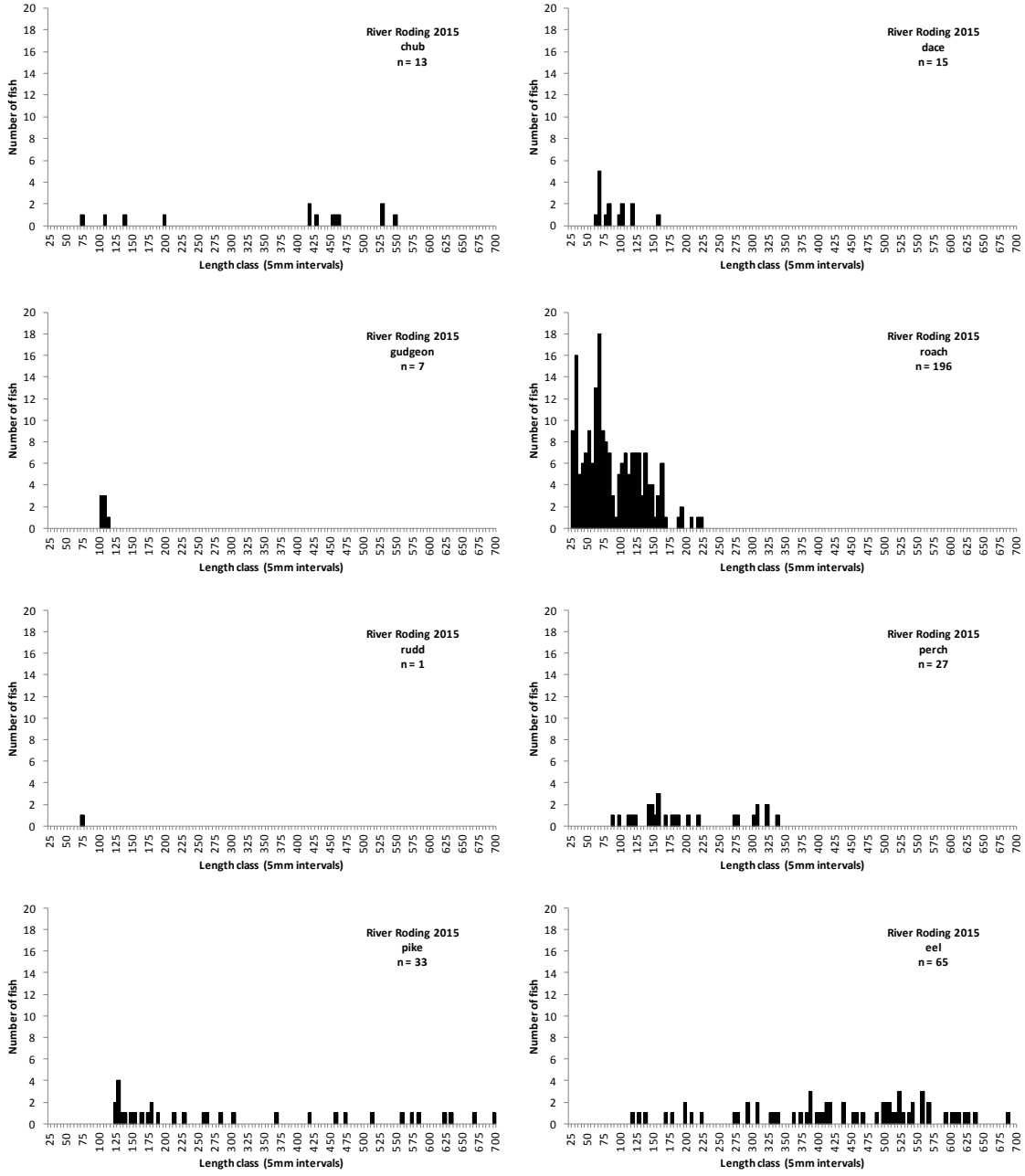

Figure 13.8: Length frequency histograms for fish species capture during 2015 surveys of the River Roding.

Seven Kings Water

Catchment overview

Seven Kings Water is a tributary of the River Roding. The river begins its course at Hainault, flowing south, south-west for approximately 11km through Fairlop, Seven Kings and Ilford before entering the Roding below Little Ilford. Two online lakes are present along the watercourse, firstly at Fairlop water and again at Loxford Water. The catchment is heavily urbanised, with the river channel culverted for significant distances above Fairlop Water and through its middle reaches further fragmenting the watercourse.

Water Framework Directive classifications

Waterbody	Fish	Invertebrates	Macrophytes	Ammonia	Dissolved Oxygen	Phosphate
Seven Kings Water	Moderate	Moderate	Not assessed	Moderate	Good	Poor

Table 17: Water Framework Directive 2015 classifications for fish and other key elements affecting fish within the Seven Kings Water WFD waterbody.

Main pressures affecting fish populations

Water quality: Ammonia, phosphate and periodically dissolved oxygen levels all impact upon resident fish populations. Misconnections from residential properties, runoff from roads and minor pollution events originating from industrial sites all contribute to poor water quality. Fairlop Water also experiences blue green algal blooms which causes further water quality deterioration within Seven Kings Water downstream of its outfall.

Morphology: The watercourse is severely fragmented. Two large online lakes at Fairlop Water and Loxford Water, combined with large scale culverting of the river channel severely limit the ability of fish to migrate throughout the river system. Tidal flap gates at the confluence of Seven Kings Water with the Roding, restrict upstream migration of many species.

Sediment: Runoff from roads entering the watercourse add significantly to the sediment load.

Water Framework Directive survey results 2015

A single site was surveyed on Seven Kings Water at Seven Kings Park for WFD classification purposes in 2015.

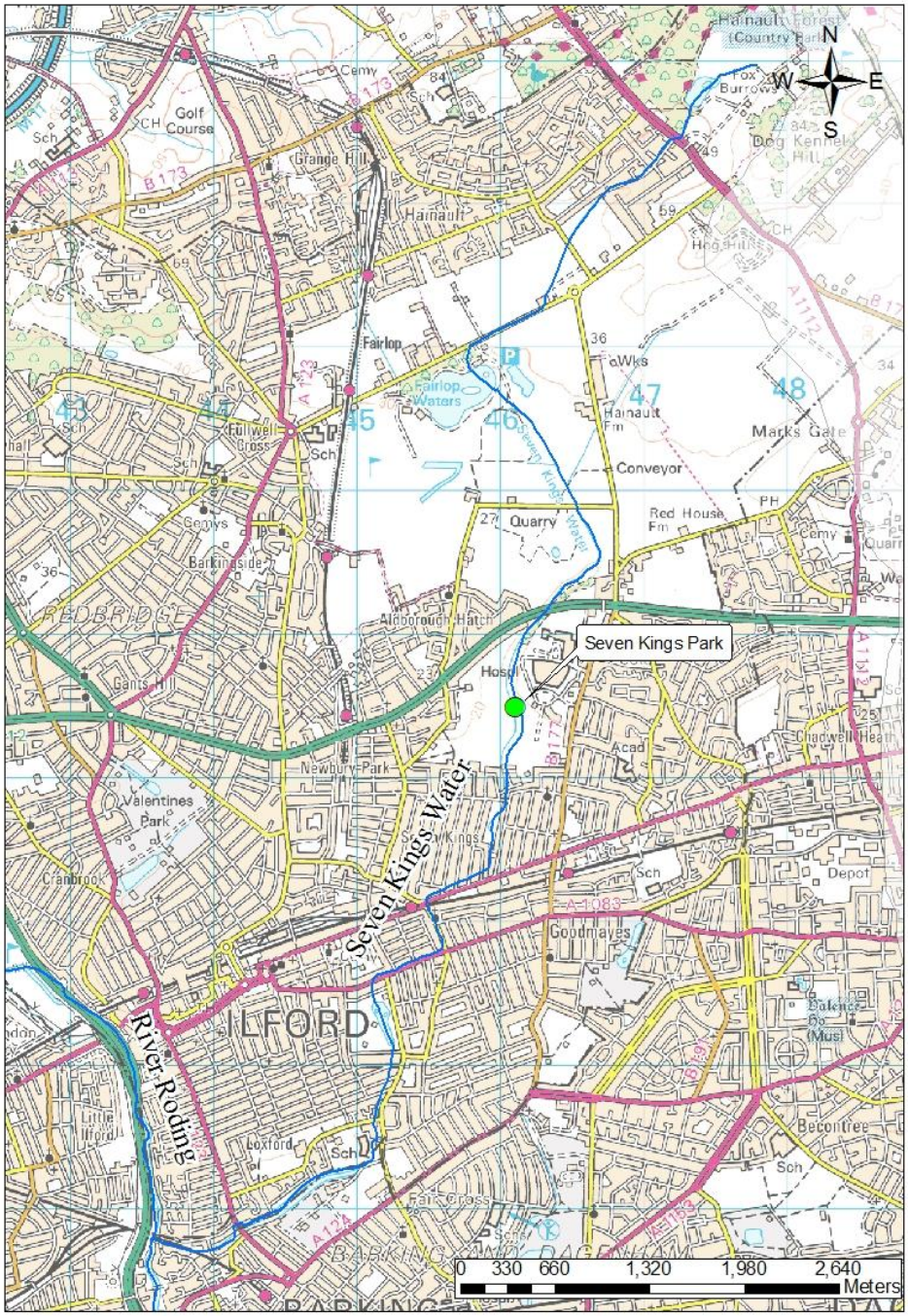

Figure 14.1: Seven Kings Water catchment showing location of Seven Kings Park fisheries monitoring site.

Site	three-spined stickleback	eel	gudgeon	perch
Seven Kings Park	17	3	27	37

Table 18: Number of each species captured in a single electric fishing run at Seven Kings Park WFD monitoring site within the Seven Kings Water waterbody 2015.

At Seven Kings Park available habitat for fish populations is limited. Towards the downstream extent the site is open with little shading of the river channel. Here blanket weed (*Cladophera spp.*) predominates, with other cover provided by areas of undercut bank. Moving upstream the channel becomes wider and increasingly shaded by trees which limit macrophyte growth. The majority of fish captured were from the downstream extent of the site where in-stream cover is greater. Perch were the most abundant species, and these were found primarily within areas of macrophyte growth. The fish population at the site is likely to be influenced more by downstream drift from Fairlop Water, which is stocked as a recreational fishery, than upstream migration. Shortly downstream of our site the channel is culverted for a distance of approximately 2km, creating a significant barrier to upstream migration, although the presence of eel at the site suggests that this does not completely exclude it.

The heavy sediment load covering much of the substrate throughout this part of Seven Kings Water is likely to limit the presence of rheophilic species which rely on clean gravel substrate in order to successfully spawn.

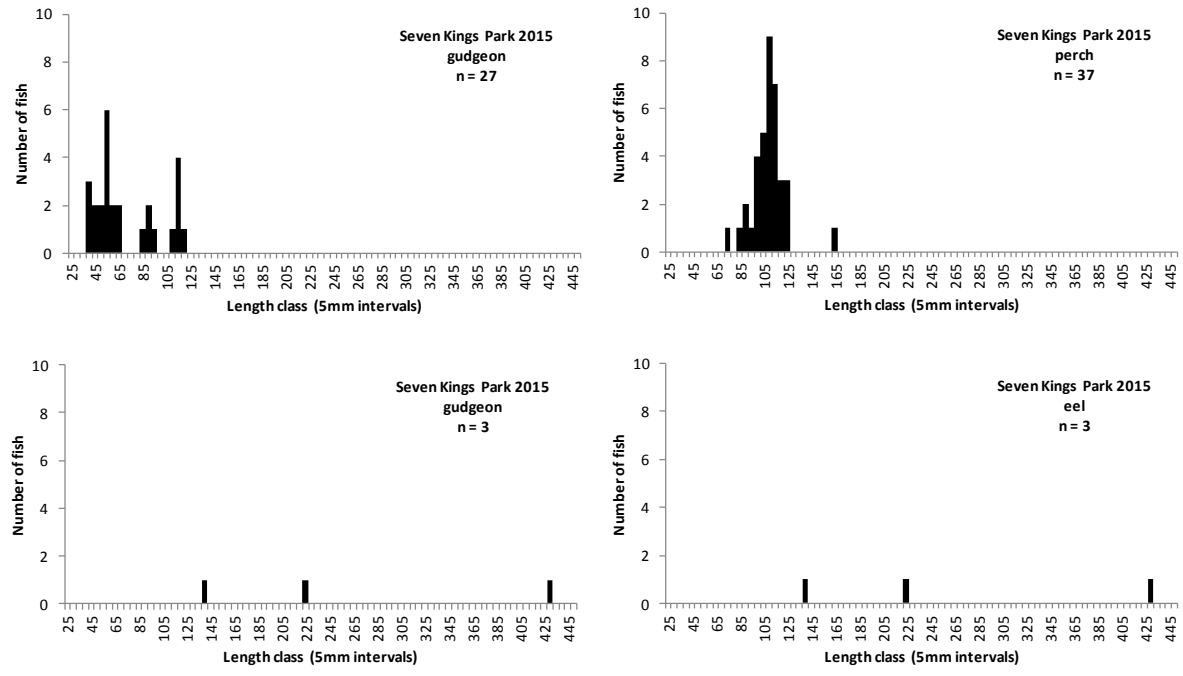

Figure 14.2: Length frequency histograms for fish species captured at Seven Kings Park 2015

River Crane

Catchment overview

The River Crane rises, initially under the guise of the Yeading Brook, to the north of Harrow, flowing south through Ruislip, Hillingdon, Hayes, Hounslow, Feltham and Twickenham before joining the River Thames at Isleworth. The main tributaries are the West and East arms of the Yeading Brook, and the Duke of Northumberland's artificial river which enters the Crane at North Feltham. The river flows for approximately 40km, draining a catchment of 104km^2.

Much of the river corridor passes through urban and suburban developments and industrial sites, most notable amongst which is Heathrow airport. In places the river also flows through significant areas of green land, such as Yeading Meadows, Hounslow Heath and Crane Park, all of which provide important conservational habitat.

Water Framework Directive classifications

Waterbody	Fish	Invertebrates	Macrophytes and Phytobenthos	Ammonia	Dissolved Oxygen	Phosphate
Crane	Poor	Moderate	Moderate	High	Good	Poor

Table 19: Water Framework Directive 2015 classifications for fish and other key elements affecting fish within the Crane WFD waterbody.

Main pressures affecting fish populations

Physical modifications: Flood defence and impounding structures significantly alter the hydrological regime of the River Crane and create significant barriers to fish migration.

Water quality: The River Crane is affected by elevated phosphate levels. Misconnected sewers are also a source of pollution into the river. Major pollution events in both 2011 and 2013 severely impacted upon both the invertebrate and fish communities present.

Investigative survey results 2015

In response to the major pollution event of 2013 which severely impacted the fish population throughout much of the River Crane, a programme of investigative surveys has been carried out at three sites to assess the recovery and current status of fish populations. This recovery has been aided by the stocking of approximately 15,000 fish from the Environment Agency's Calverton fish farm since 2013.

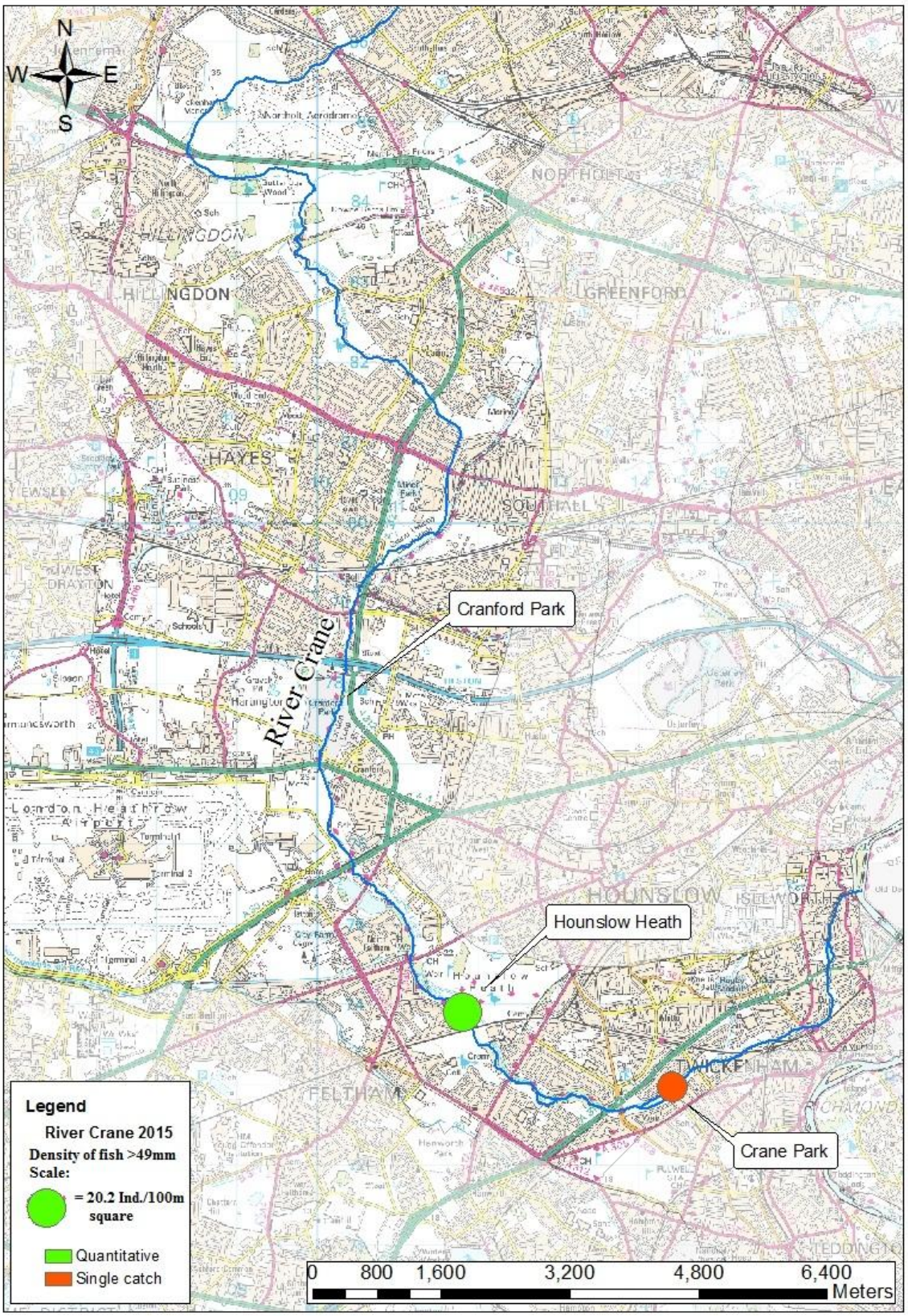

Figure 15.1: River Crane catchment showing location and comparative density of fish species >49mm at fisheries monitoring sites 2015.

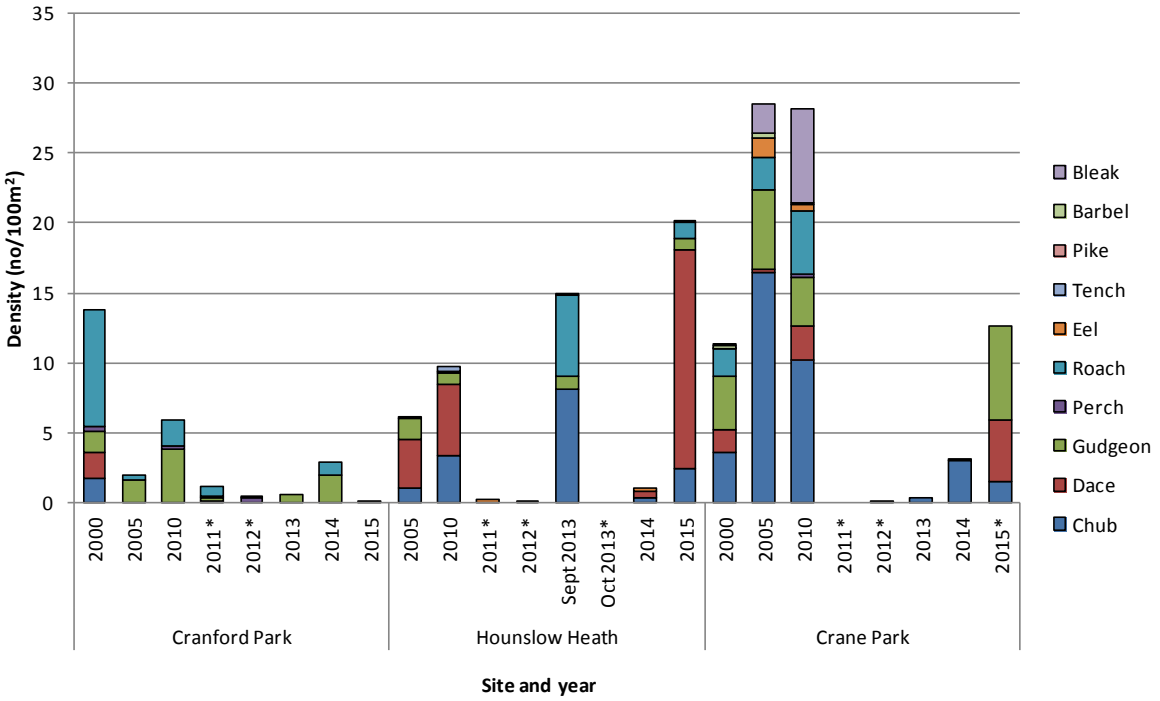

Figure 15.2: Density of fish species >49mm at monitoring sites on the River Crane 2000 – 2015 (*denotes results based on a single catch and not a quantitative estimate)

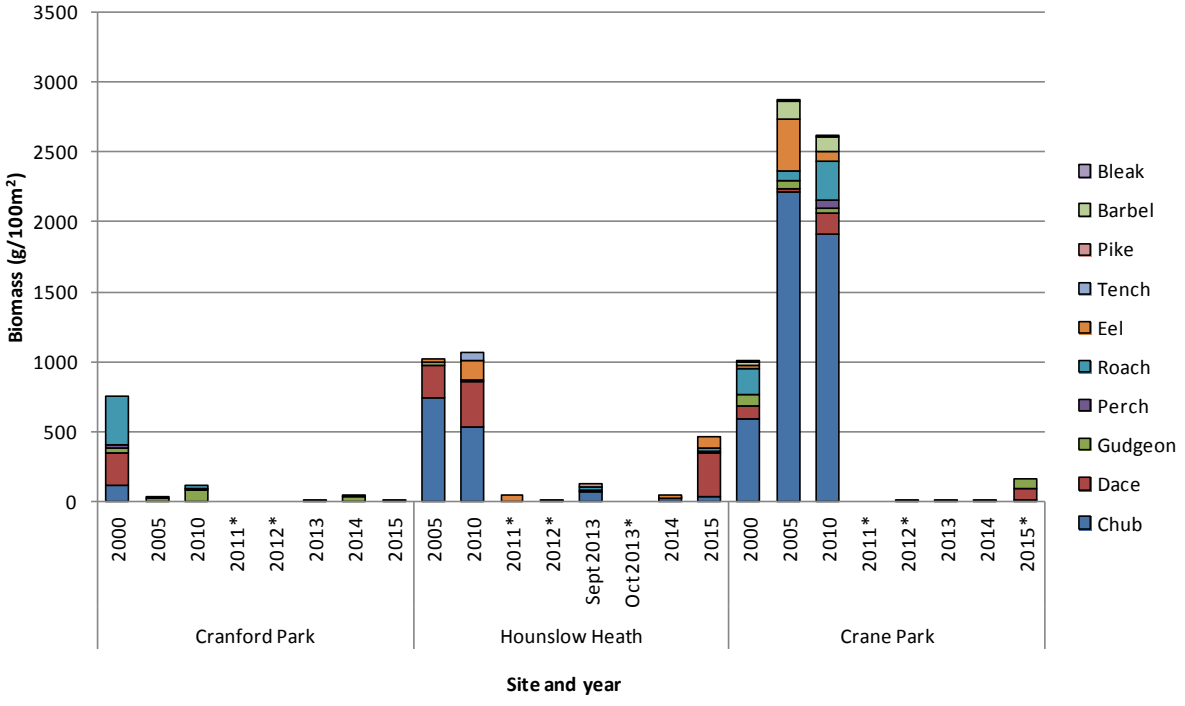

Figure 15.3: Biomass of fish species >49mm at monitoring sites on the River Crane 2000 – 2015 (*denotes results based on a single catch and not a quantitative estimate)

Cranford Park	2005	2010	2011	2012	2013	2014	2015
Bullhead	0	0	10-99	0	0	0	1-9
Minnow	191	100-999	100-999	100-999	100-999	100-999	100-999
Three-spined stickleback	64	10-99	10-99	0	10-99	10-99	0
Stone loach	2	10-99	10-99	0	10-99	10-99	10-99

Hounslow Heath	2005	2010	2011	2012	Sept 2013	Oct 2013	2014	2015
Bullhead	0	10-99	2	10-99	10-99	0	10-99	100-999
Minnow	12	10-99	0	100-999	1000-9999	0	1000-9999	100-999
Three-spined stickleback	1	0	2	100-999	10-99	1-9	10-99	0
Stone loach	2	10-99	0	10-99	100-999	1-9	10-99	10-99

Crane Park	2005	2010	2011	2012	2013	2014	2015
Bullhead	0	1-9	0	10-99	0	0	10-99
Minnow	10-99	100-999	1-9	100-999	0	100-999	100-999
Three-spined stickleback	0	1-9	0	0	10-99	10-99	10-99
Stone loach	1-9	10-99	0	10-99	0	10-99	10-99

Table 20: Numbers of minor species recorded during surveys of the River Crane 2000 – 2015 (numbers in some survey years given as log abundance estimates)

Results of the 2015 survey of the River Crane suggest that fish populations are beginning to recover. The effects of two successive stockings of chub, dace, roach and barbel in December 2013 and December 2014, consisting cumulatively of in excess of 15,000 fish has no doubt assisted in this recovery.

Cranford Park is located upstream of the area affected by either the pollution event of 2011 or 2013. The site had been surveyed prior to this time, and its inclusion in our post-pollution monitoring was aimed at providing a continuum of the baseline data already collected, as well as an unaffected site against which the recovery of affected sites could be gauged. Fish populations when first surveyed in 2000 were far healthier than at present. In recent years habitat quality for fish has deteriorated with the site now overgrown and heavily shaded limiting photosynthetic productivity. Better habitat for fish is to be found a short distance upstream of our site. In 2015 the catch consisted of a solitary chub of 139mm, and the minor species, bullhead, stone loach, and minnow.

Density of fish >49mm was the highest to date at **Hounslow Heath**, and is in fact higher than prior to the first major pollution event of 2011. Dace were the most abundant species at the site with 110 captured during the course of the survey. The shallow, briskly flowing water over a clean gravel substrate found throughout the site provides habitat well suited to the species. The size of dace captured, averaging 116mm, suggests they are stocked fish. In addition 16 small chub, and 8 small roach, again are likely to be stocked fish were captured, as well as naturally re-colonising gudgeon and eel were also captured. The site is open with limited cover, and this may limit its utilisation by other stocked species such as chub and barbel.

At **Crane Park** results of surveys carried out between 2000 and 2010 suggest that the site previously supported the highest density, biomass and species diversity of the three sites surveyed. In 2010, the year preceding the first major pollution event, a total of 12 fish species including minor species were captured. In 2015 results of the survey are based on a single electric fishing run and as such are likely to under-represent the true status of the fish population present. Although not quantitative results suggest that density of fish >49mm is the highest since 2010. Species diversity is still low in comparison with pre- pollution levels, with chub, dace, gudgeon, bullhead, stone loach, minnow and three-spined stickleback captured in 2015. However, it is encouraging that natural re-colonisation of species such as gudgeon, which were found in the highest numbers of any major species in 2015, having been absent in 2014. The 2014 survey also revealed evidence of natural recruitment of chub occurring in the vicinity of the site with 83 juvenile chub with a mean length of 45mm captured. Due to the inefficiency of electric fishing as a capture method for fish of this size and the related difficulty in obtaining accurate population estimates, they are not represented within the results shown in Figures 15.2 and 15.3.

Although density results suggest signs of recovery at both sites, biomass still falls some way short of pre-pollution levels, and is indicative of the fact that those fish present are predominantly young stock fish. Biomass at Crane Park and Hounslow Heath was heavily influenced by the presence of large individuals of species such as chub. The recovery of fish stocks to include larger individuals will occur naturally over time as stocked fish grow on.

Table 20 details the abundance of minor species at each of our sites on the River Crane. The fact that these species are both small and can be incredibly abundant, means that obtaining accurate quantitative population estimates can be extremely difficult. As such log abundance estimates of numbers are instead recorded. The ability of these species to rapidly re-colonise is clear. At both Hounslow Heath and Crane Park estimated abundance of minor species had returned to, or exceeded, pre-pollution event levels within a year. Booming populations of minor species may occur in response to a reduction in populations of larger cohabiting species, and the pressures from predation and competition that they may exert.

Figure 15.4 details length frequency histograms for fish species captured in 2015, and comparative length frequency histograms from the 2014 survey. The increase in gudgeon which have not been stocked is particularly encouraging, whilst numbers of dace captured is far higher than in 2014. For chub the large numbers of juveniles captured in 2014 were not replicated in 2015. However a greater number of larger chub were captured. Roach numbers are comparable to those captured in the 2014 survey.

Barbel which have been stocked over the last two winters have not featured in any of our surveys. The habitat found within our survey sites is likely to be the main reason for this, with Hounslow Heath and Crane Park offering little in the way of cover, with areas of river providing greater depth of water and increased cover from submerged macrophyte beds and riparian vegetation likely to be sought out by the species during its juvenile life stage.

It is hoped that an additional stocking of approximately 8,000 fish, introduced to the river in December 2015, will assist further recovery of fish stocks.

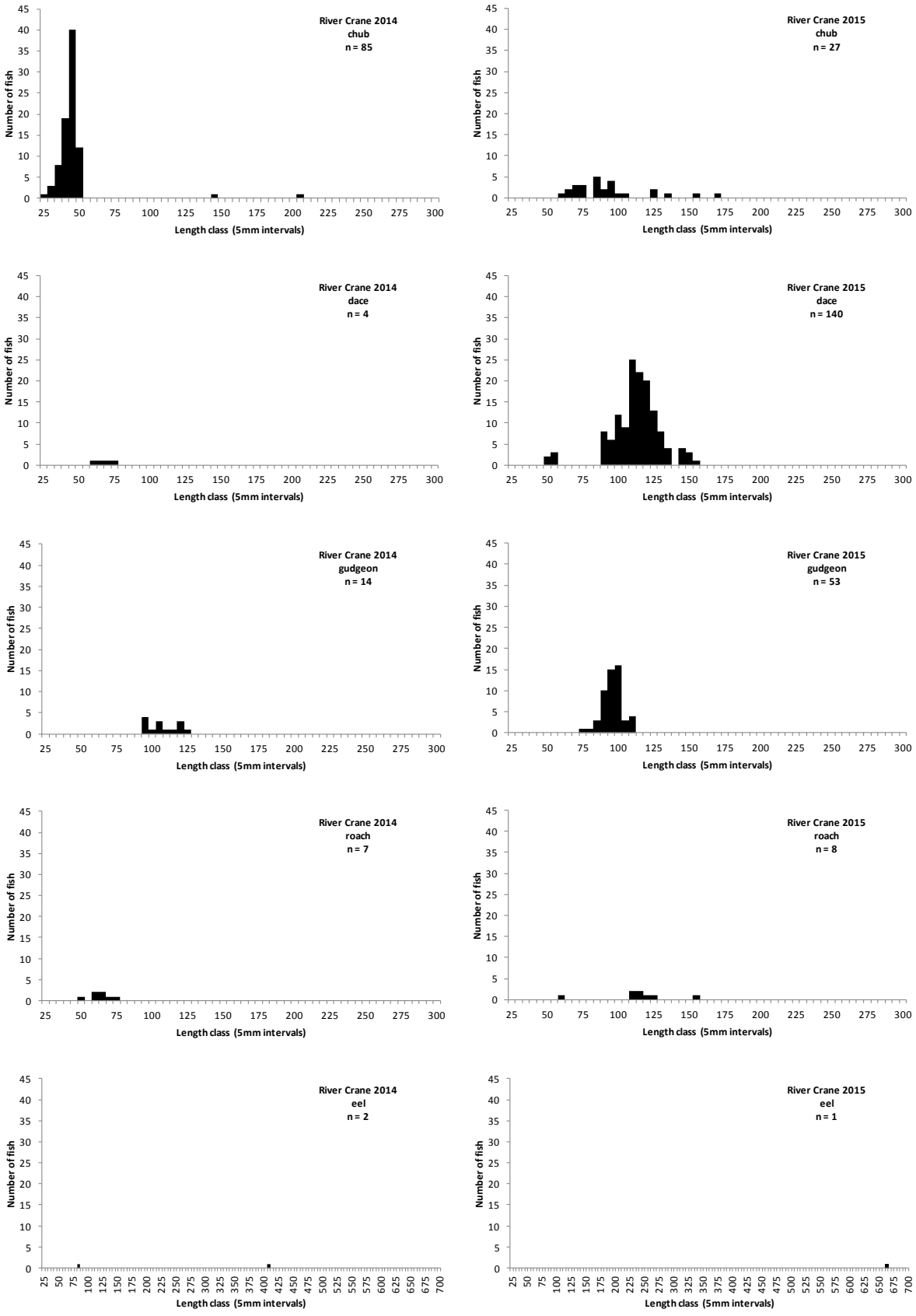

Figure 15.4: Length frequency histograms for fish species captured during the 2015 survey of the River Crane and comparative length frequencies from 2014.

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