Fish population survey report

River Bure (central) 2019 (Spatial)

This report provides a summary of results from recent fish population surveys on the River Bure between Aylsham and Horstead. Data from five surveys conducted in 2019 assess the health of the river to enable successful management of this principal fishery.

Image 1. View downstream from Oxnead Bridge towards Oxnead Mill and sluices.

The Environment Agency has a duty to maintain, improve and develop fisheries. Part of that duty is to ensure the diversity of coarse and migratory freshwater fish, and the conservation of their habitat. In order to manage fish stocks, the Environment Agency regularly monitors fish populations in major river systems.

This report looks at fish data obtained in 2019 for the fish population in the River Bure. Data from 5 sites, currently surveyed on a three year schedule, are analysed and reported for WFD and fishery management perspectives. In addition, an analysis of long-term trends and cycles over the central section of the river and at individual site level are undertaken using historic data obtained from annual and 3 yearly survey schedules.

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Sign-off date	August 2021

Summary (2019)

- Five spatial sites, surveyed under a three yearly schedule, on the River Bure were surveyed using Pulsed Direct Current (PDC) electric fishing methodology between May and June 2019;
- 14 species of fish were present (bullhead, chub, dace, eel, gudgeon, lamprey, perch, pike, roach, rudd, stickleback, stone loach, tench and trout)
- In total 959 fish were recorded; of which 364 were above 99 mm Fork Length (FL) (see Factors affecting survey results).
- In the 2019 surveys, eel, gudgeon and pike over 99 mm FL are recorded from all sites;
- Based on fish over 99 mm FL, an average density estimate of 3.77 fish per 100 m^2 and biomass estimate of 1347 grams per 100 m^2 were recorded across all sites;
- Roach were the most numerous species, whilst chub had the highest overall biomass.
- WFD indicator species are present in the river (bullhead, eel, lamprey, stone loach, stickleback & trout).

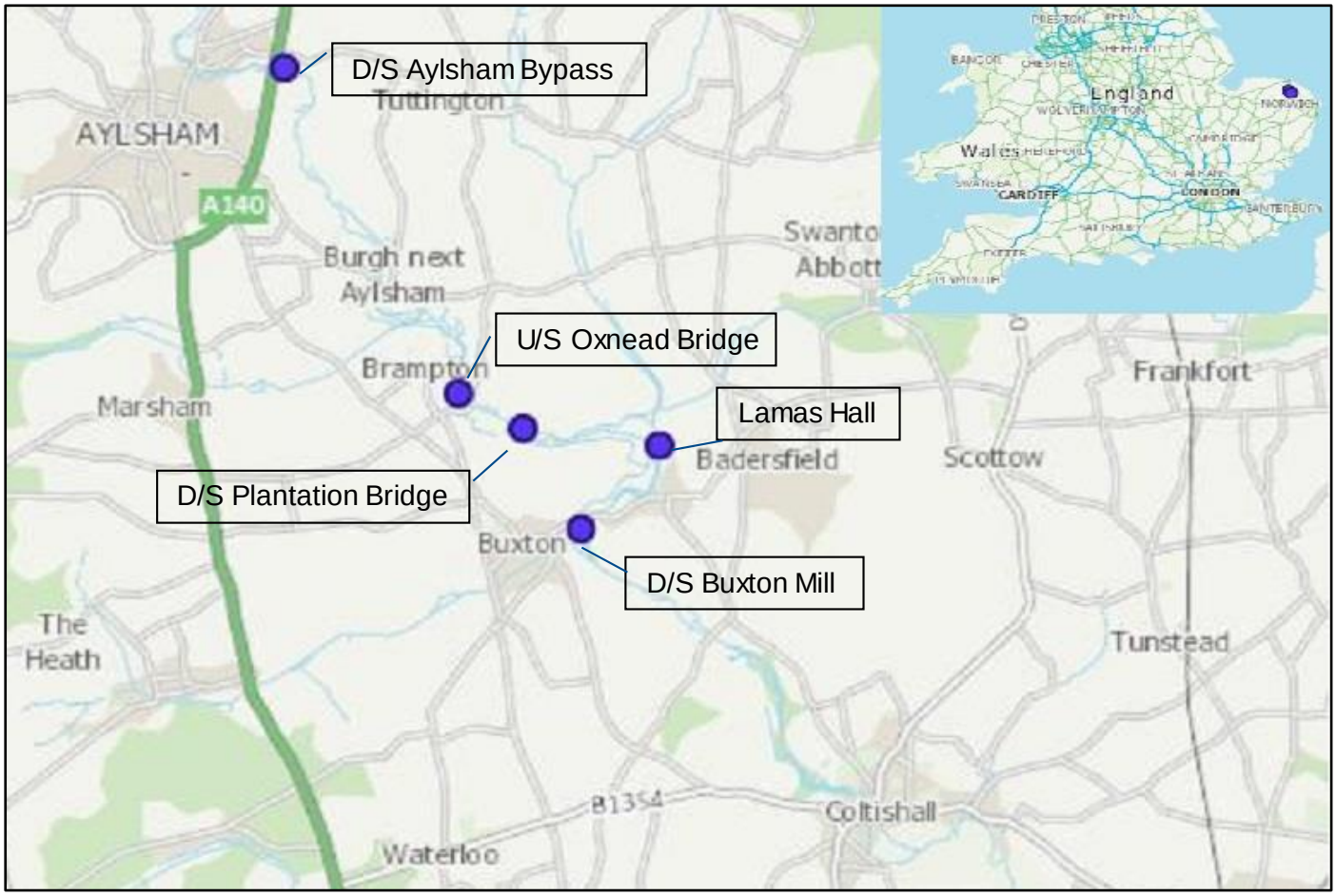


Figure 1:
Map showing the five River Bure survey sites and location of River Bure in Norfolk, United Kingdom.

Site locations

Table 1 Site details (name of survey site, date of survey, survey location and survey area) as shown on map (Figure 1).

Site name	Survey date	Survey area (m^2)	Location (NGR)
D/S Aylsham Bypass	15/05/2019	1480	TG2068427560
U/S Oxnead Bridge	09/05/2019	2310	TG2247624158
D/S Plantation Bridge	21/05/2019	1725	TG2313923792
Lamas Hall	10/06/2019	2432	TG2454323614
D/S Buxton Mill	20/05/2019	1870	TG2373522742

Factors affecting survey results

Survey sites: Barriers exist along the central section of the River Bure that create isolated fish populations. Few fish species recorded are able to migrate freely between the isolated sections of the river. The same barriers to fish migration provide a mix of habitats: above the barriers over-deep, ponded areas, with slow flows and sediment substrate exist, while deep pools containing scoured clean gravel, rapidly shallowing to fast flowing water over riffles are present below. In view of these aspects, survey site selection requires careful consideration to ensure the site is representative of all hydro-morphological and habitat features present.

All sites are surveyed using electric fishing methodology with a minimum of 2 separate passes at each site to measure catch depletion. Capture efficiency using electric fishing methods is less effective for fish below 99 mm FL. Historically fish over 99 mm FL are used to generate report data and estimates. This report concentrates on key fish species over 99 mm FL. That said, reference to fish less than 99 mm FL is made where their inclusion adds benefit to the report (spawning success, recruitment). WFD indicator species tend to be less than 99 mm FL; when recorded they too are included in this report.
Water clarity at the time of all surveys was good. Macrophyte growth varied from site to site, with very little in stream growth evident at D/S Aylsham Bypass. In contrast, dense macrophyte growth was evident at Lamas Hall, & D/S Buxton Mill; trained staff mitigated the effect of dense weed growth at these sites preventing adverse effects to survey results.

All survey sites require a 4-man team to fish the sites effectively. Survey teams comprised fully trained and experienced officers. Comparisons between the actual 2019 capture data and theoretical depletion sampling estimates (Carle & Strubb) indicate that the 2019 data from all surveys are within 10% of C&S estimates. This provides a high degree of confidence in the collected data and its robustness for statistical analysis. Carle and Strubb estimates are reported here.

Table 2: **Maximum size of 6 key species recorded at each survey site based on fish over 99 mm Fork Length (FL) and number of fish recorded. Maximum size for each species highlighted by yellow cell colour and bold type. Greatest number of each species across all sites highlighted in bold type.**

Site name / Species	D/S Aylsham Bypass	U/S Oxnead Bridge	D/S Plantation Bridge	Lamas Hall	D/S Buxton Mlll
Chub (max length)	0	0	0	0	**552**
No. caught	0	0	0	0	**26**
Dace (max length)	0	**195**	**195**	127	191
No. caught	0	4	9	2	**11**
Perch (max length)	0	168	**280**	253	255
No. caught	0	1	8	1	**9**
Pike (max length)	578	738	**962**	654	652
No. caught	2	20	15	15	**21**
Roach (max length)	111	0	141	**268**	142
No. caught	1	0	**85**	72	2
Trout (max length)	**488**	0	400	0	0
No. caught	**6**	0	2	0	0
Other species	3sst, Bh, E Gud, St lo	E, Gud, St lo	E, Gud, L	E, Gud, St lo, Te	E, Gud, L, St lo, Te

Key: 3sst = 3 spined stickleback, Bh = Bullhead, E = Eel, Gud = Gudgeon, L = Lamprey (sp), St lo = Stone loach, Te = Tench

2019 Survey results

Largest fish from the surveys: (**Table 2**)

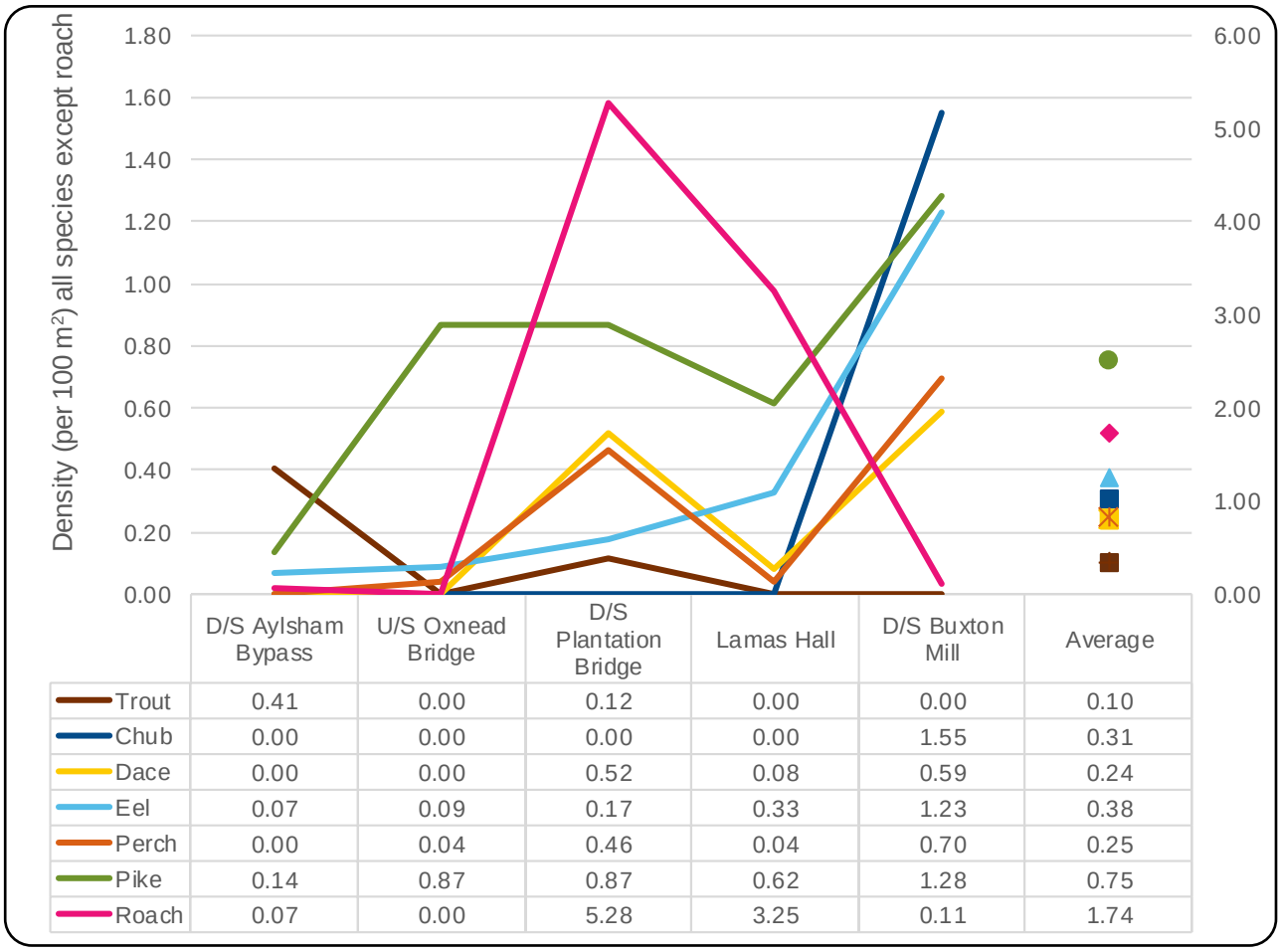
- Chub, 552mm FL recorded at D/S Buxton Mill. Weight: 5 lbs (2.63 Kg)
- Dace, 195 mm FL recorded at U/S Oxnead Bridge and D/S Plantation Bridge. Weight 4 ozs (0.09 Kg)
- Perch, 280 mm FL recorded at D/S Plantation Bridge. Weight 1 lb (0.9 Kg)
- Pike, 963 mm FL recorded at D/S Plantation Bridge. Weight 19lbs 4ozs (8.86 Kg)
- Roach, 268 mm FL recorded at Lamas Hall. Weight 14 ozs (0.39 Kg)
- Trout, 488 mm FL recorded at D/S Aylsham Bypass. Weight 2lbs 10ozs (1.1Kg)
- No chub, dace or perch over 99 mm FL are recorded from D/S Aylsham Bypass

Highest number of fish from an individual site and total number caught across all sites surveyed: **(Table 2**)

- 85 roach recorded from D/S Plantation Bridge; 160 fish in total from 4 of the 5 sites
- 11 dace from D/S Buxton Mill; 26 caught across 4 of the 5 sites
- 21 pike recorded from D/S Buxton Mill; combined total of 73 individuals across all sites
- 26 chub caught at D/S Buxton Mill; no other site recorded chub
- 6 Trout caught from D/S Aylsham Bypass; 8 fish in total caught across 2 sites
- 9 perch caught from D/S Buxton Mill: 19 fish in total from 4 sites

Pike, gudgeon and eel are present at every site.

2019 Density estimates



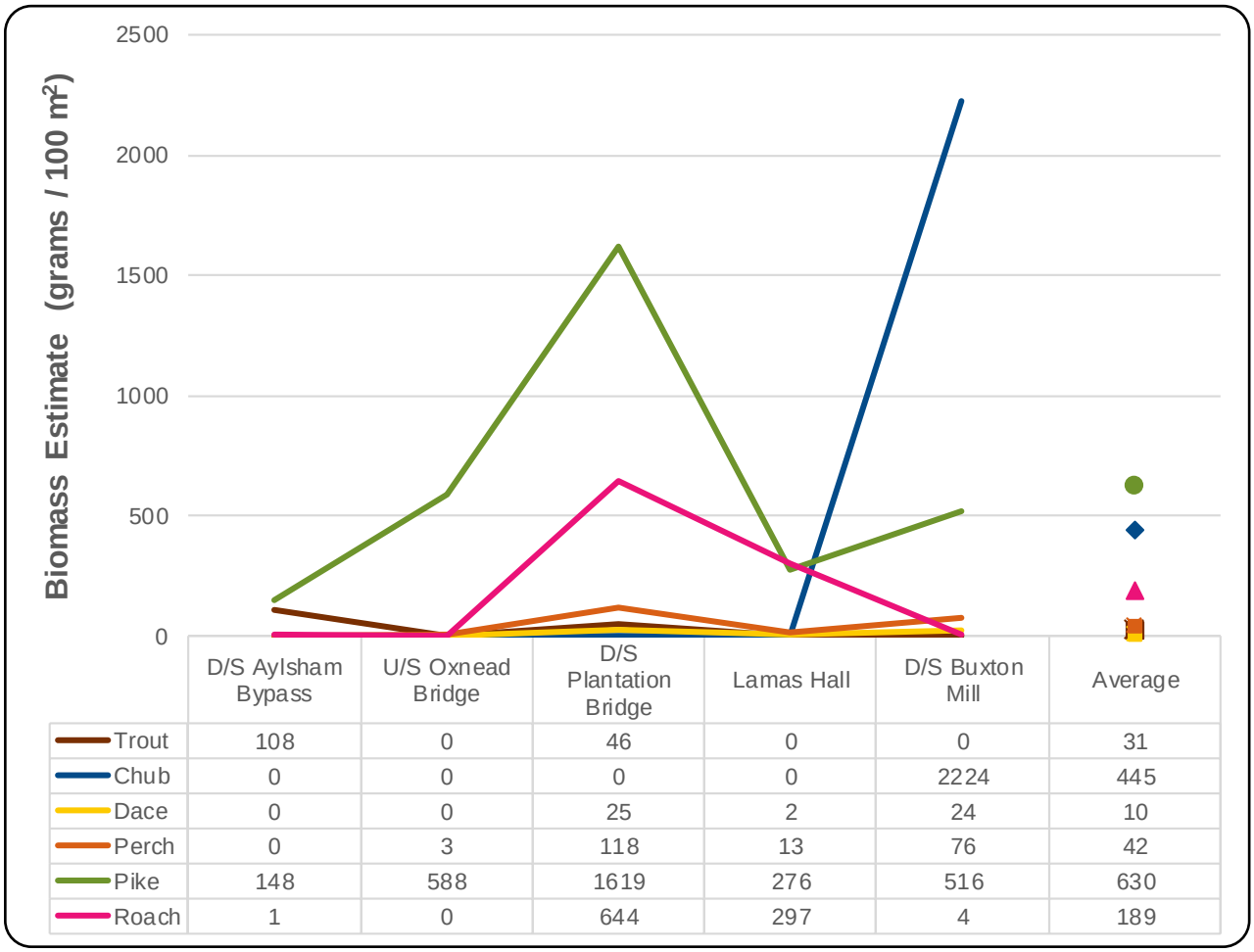
	D/S Aylsham Bypass	U/S Oxnead Bridge	D/S Plantation Bridge	Lamas Hall	D/S Buxton Mill	Average
Trout	0.41	0.00	0.12	0.00	0.00	0.10
Chub	0.00	0.00	0.00	0.00	1.55	0.31
Dace	0.00	0.00	0.52	0.08	0.59	0.24
Eel	0.07	0.09	0.17	0.33	1.23	0.38
Perch	0.00	0.04	0.46	0.04	0.70	0.25
Pike	0.14	0.87	0.87	0.62	1.28	0.75
Roach	0.07	0.00	5.28	3.25	0.11	1.74

Figure 2 Density estimates of key species from each site. Estimates derived using fish over 99 mm FL. Average estimate for each species shown for comparison (average estimate of dace and perch lie on top of each other on chart). NB Roach density estimate shown on secondary axis for clarity.

Observations: (Figure 2)

- Figure 2 indicates markedly different roach and dace density estimates between the 5 sites (see also figure 3, biomass estimates).
- Highest roach densities in 2019 occur at D/S Plantation Bridge and Lamas Hall; respectively 5.28 & 3.25 fish per 100 m^2
- Eel density peaks at D/S Buxton Mill site: 1.23 fish per 100 m^2
- Trout density peak (0.31 fish per 100 m^2) occurs at the furthest upstream site, D/S Aylsham Bypass. Six of the 8 trout caught across all surveys were recorded here
- Dace density is highest at D/S Buxton Mill site; the furthest downstream site
- Highest densities for chub, dace, eel, perch, and pike are reported from D/S Buxton Mill site

2019 Biomass estimates



	D/S Aylsham Bypass	U/S Oxnead Bridge	D/S Plantation Bridge	Lamas Hall	D/S Buxton Mill	Average
Trout	108	0	46	0	0	31
Chub	0	0	0	0	2224	445
Dace	0	0	25	2	24	10
Perch	0	3	118	13	76	42
Pike	148	588	1619	276	516	630
Roach	1	0	644	297	4	189

Figure 3: Biomass estimate values for key species at each site. Estimates based on fish over 99mm FL. Average estimates shown are calculated using species data from all sites. Average estimates for dace, perch and trout are similar and obscure each other where plotted.

Observations: (Figure 3)

- Pike biomass is highest at D/S Plantation Bridge. The biggest individual pike is recorded from this site (Table 2).
- Roach biomass is highest at D/S Plantation Bridge, roach biomass declines at the 2 sites further downstream.
- Pike are the foremost species by biomass at 3 of the 5 survey sites
- Chub biomass peaks at D/S Buxton Mill
- Pike biomass at D/S Plantation bridge is 2.7 times that of U/S Oxnead Bridge despite recording the same density estimates (see figure 2, data table)

- Trout biomass is highest at D/S Aylsham Bypass, however pike biomass at this site is the lowest recorded across all sites

Comments / interpretation; 2019 survey data.

A number of points observed in Figures 2 & 3 require comment and interpretation.

Chub are only present below Buxton Mill which may indicate Buxton Mill is a significant barrier to upstream migration (Figure 2 & 3). Despite their presence at only one site in 2019, chub biomass estimate exceeds the combined biomass estimates of all other species except pike from all surveys (Figure 3; Data table). Additionally chub biomass at D/S Buxton Mill rivals the combined biomass of pike from all sites: approximately 70% of the total pike biomass (Figure 3). The significant biomass and density of chub recorded in 2019 could be due to a delay in spawning: high numbers of full-bodied chub made up the catch (pers obs). The mix of cohorts caught indicate that chub thrive in the River Bure between Buxton Mill and Horstead.

Pike density estimates at 4 of the 5 sites is relatively high, demonstrating stock resilience for the future, while biomass estimates indicate continued individual growth and recruitment to the stock (Figures 2 & 3). Biomass estimate at D/S Plantation Bridge (Figure 3) indicates that pike present at the site are large fish compared to individuals recorded at U/S Oxnead Bridge, Lamas Hall and D/S Buxton Mill sites (comparison of density and biomass for each site: Figures 2 & 3). Pike biomass at Lamas Hall is less than an eighth of that recorded at D/S Plantation Bridge suggesting a change in pike size distribution (Figure 3). The higher than average number of prey (roach, dace) at D/S Plantation Bridge in 2019 (Figure 2) may help explain the presence of large pike at the site.

Roach density estimate at 2 sites (D/S Plantation Bridge and Lamas Hall); both situated in the same section of river, account for 98% of the combined roach density estimate for the central section of the River Bure in 2019 (Figure 2). The very high density (and biomass) estimates at these sites is out of character (Figures 12, 13, 14 & 15). Long-term data indicate roach presence at both sites but their combined density estimate is usually significantly lower than 30% of the combined total across the 5 sites. With the exception of D/S Aylsham Bypass, long-term data indicates an even distribution of roach throughout this section of the River Bure.
The absence of roach in the 2019 survey at U/S Oxnead Bridge is both significant and unusual (Figure 3); long-term site data indicates continuous roach presence at the site since 2003 ~ 2016 and moderate density estimates when present (figure 10).

Long-term density and biomass estimates

Notes: The River Bure is a Principle Course Fishery. Data from 5 core sites form the basis of this report. Prior to 2010, surveys took place annually providing a temporal data set. Since 2010, the same 5 sites are surveyed on a 3 year survey schedule providing a spatial data set. Data from the sites surveyed in each year produce the long-term density and biomass estimate charts.

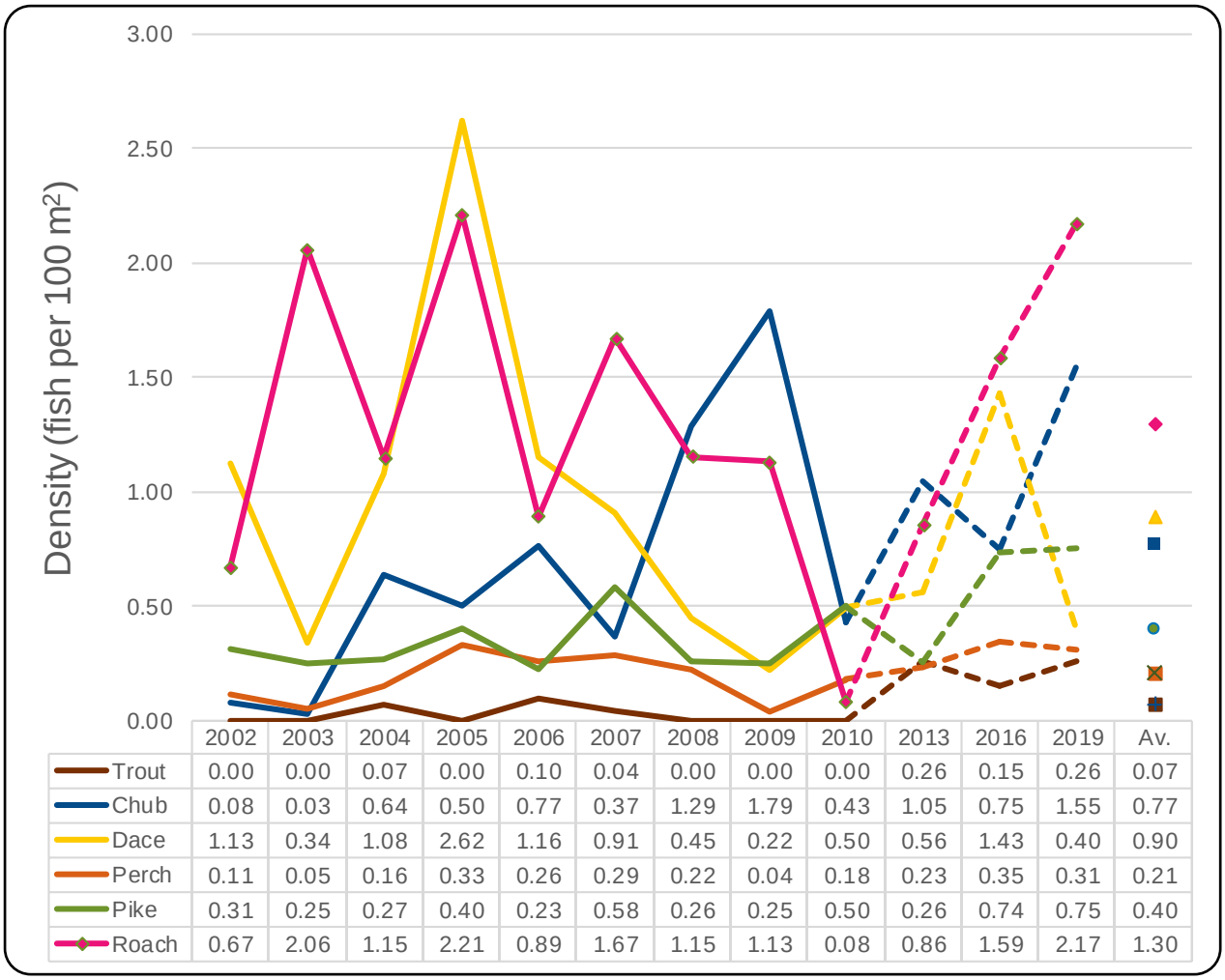
Between 2002 and 2019, a single survey is missing from an otherwise complete and comprehensive survey record. The missing survey is for Lamas Hall in 2009. Results from D/S Plantation Bridge are often similar to results obtained from Lamas Hall and for 2009 serve as a proxy for Lamas Hall. The following sections use the data collected from the 59 completed surveys.

Survey area and rationalisation:

Survey length at each site is in accordance with Environment Agency (EA) codes of practice based on UKTAG guidelines; most recently a minimum of 150 metres surveyed length across the full width of the river. However, survey area at many of the sites has reduced over time due to hydro-morphological changes in river width. The use of density estimates (fish per 100 m^2) alleviates discrepancies resulting from differences in survey area and allows direct comparison between sites and species regardless of survey area. The same rationale applies to biomass estimates ie grams per 100 m^2.

Long-term density estimates

Observations: long-term density estimates (Figure 4)



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	Av.
Trout	0.00	0.00	0.07	0.00	0.10	0.04	0.00	0.00	0.00	0.26	0.15	0.26	0.07
Chub	0.08	0.03	0.64	0.50	0.77	0.37	1.29	1.79	0.43	1.05	0.75	1.55	0.77
Dace	1.13	0.34	1.08	2.62	1.16	0.91	0.45	0.22	0.50	0.56	1.43	0.40	0.90
Perch	0.11	0.05	0.16	0.33	0.26	0.29	0.22	0.04	0.18	0.23	0.35	0.31	0.21
Pike	0.31	0.25	0.27	0.40	0.23	0.58	0.26	0.25	0.50	0.26	0.74	0.75	0.40
Roach	0.67	2.06	1.15	2.21	0.89	1.67	1.15	1.13	0.08	0.86	1.59	2.17	1.30

Figure 4: Density estimates for 6 key species from 2002 ~ 2019 averaged across all sites. Dotted lines denote change from annual to 3 yearly survey schedule. Long-term average value shown for comparative purpose.

Roach

- 2019 was a good year for roach, almost equalling the peak in 2005.
- Roach density estimates display a 2 year cyclic pattern over the 2002 ~ 2009 period. The significant decline observed in 2010 marks a change in the pattern with subsequent estimates indicating year on year increases culminating in the 2019 estimate.
- In most cases when roach density is low, few if any fish over 99mm FL are captured from 3 of the 5 sites. Conversely, high roach density estimates relate to years when roach over 99 mm FL are recorded from all sites.
- Smaller roach (less than 99 mm FL) are recorded from most sites in most years.

Dace

- Dace density in 2005 is the highest of any species in any of the surveys
- The stand out year for dace is 2005 with a smaller peak in 2016. 2019 sees a decline to a low level.
- Dace density estimate seems in most years to mimic the captures at D/S Plantation bridge site; high numbers at this site drive high average estimates for the year. However, few juvenile dace (less than 99 mm FL) are caught here.

Pike

- Pike density is relatively stable over the period 2002 ~ 2010; staying for the most part within the range of 0.25 ~ 0.5 fish per 100 m^2. Density estimates in 2016 and 2019 are due to increased numbers recorded across all sites (Figure 4 and data table).
- Pike are most abundant at 3 sites: U/S Oxnead Bridge, D/S Plantation Bridge and D/S Buxton Mill.
- Pike density at D/S Aylsham Bypass is usually the lowest density across all sites.

Chub

- With the exception of 2004 & 2005, all the chub recorded over the selected period originate from one site: D/S Buxton Mill. The only other site to record chub is Lamas Hall, the survey site above Buxton Mill.
- Chub density estimates fluctuate considerably, ranging between 0.03 ~ 1.79 fish per 100 m^2 with an overall trend of increase.
- In many years, chub density exceeds that of pike and perch. Since 2008, chub density estimate consistently features among the 3 top species and in 3 years is the highest density of any species.
- In 2019, chub density displays a rapid increase to twice the long-term average estimate.

Perch

- Perch density estimates, like those of pike, display variations over the long-term starting from a low base (Figure 4) but rarely exceeding 0.3 fish per 100 m^2. Analysing the source data it is apparent perch captures are sporadic over time and across sites. In some years, perch feature at all sites, while in other years perch density is based on captures from one site.
- The site with lowest occurrence is D/S Aylsham Bypass – only captured twice over the 12 years (2002 & 2010).
- Perch density estimate in 2016 & 2019 is above 0.3 fish / 100 m^2: over thirty percent higher than the long-term average density estimate.
- Perch density estimates indicate a possible 6 year trend. The lowest density estimates of similar magnitude occur in 2003 and 2009 with a higher plateau evident between those years. In 2010 a comparable rise is shown to that of 2004 but survey timings preclude further support as to whether this represents a similar cycle to previous years.

Trout

- Trout are not prolific in the central section of the river Bure. The lack of available spawning habit allied to slow flow regime does little to support natural populations. Most of the trout seen and caught by anglers reside in areas of fast, turbulent flows. They favour the furthest upstream site, D/S Aylsham Bypass; recorded in 7 of the 12 surveys conducted there (see also site level results: D/S Aylsham Bypass). In contrast, trout are totally absent from the 12 catch records at the furthest downstream site, D/S Buxton Mill.
- Trout over 99 mm FL are absent from any site in 5 of the 12 survey periods (2002, 2005, 2008, 2009 & 2010).
- The 3 highest density estimates recorded in 2013, 2016 and 2019 result from high numbers of trout caught at D/S Aylsham Mill and D/S Plantation Bridge sites.

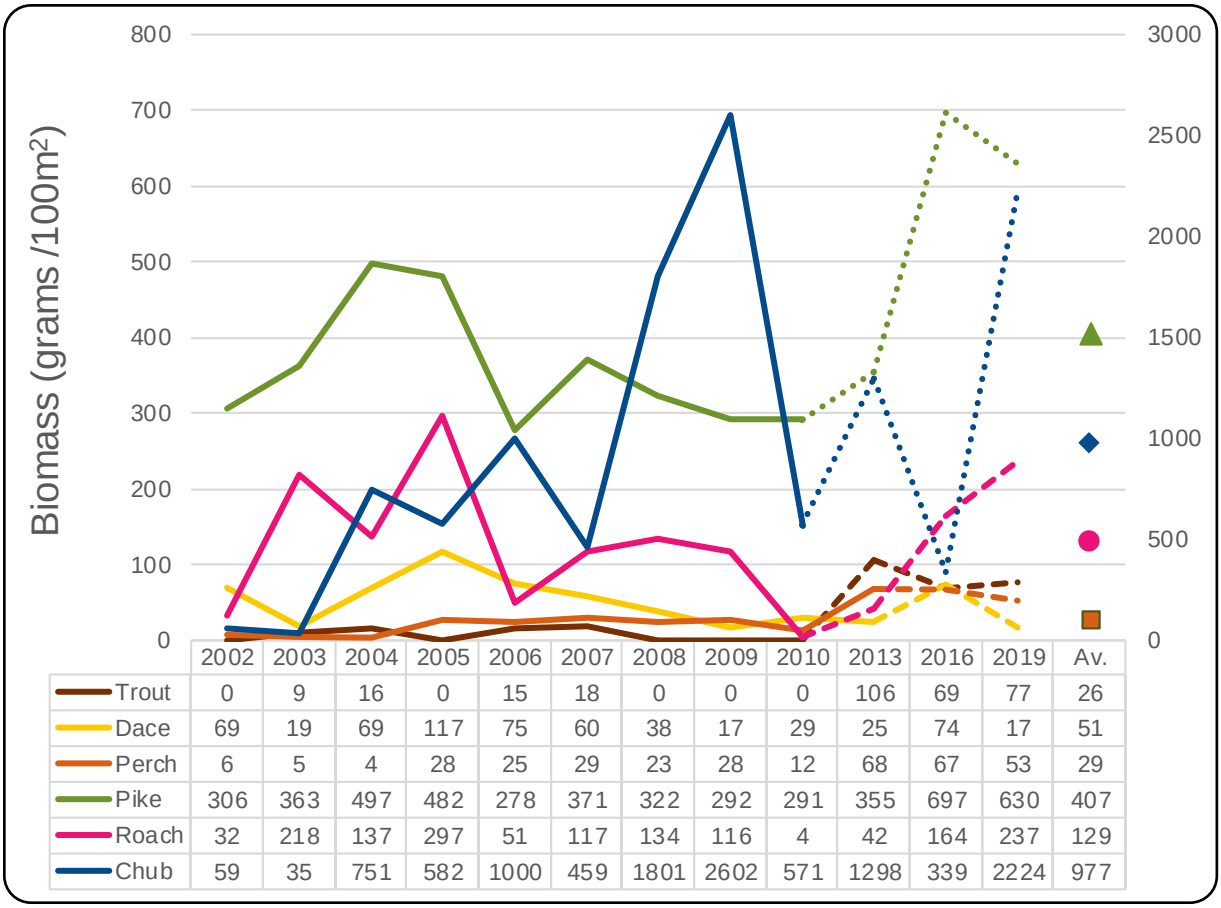
Long-term biomass estimates

Observations: long-term biomass estimates **(Figure 5)**

Roach

- Variations in roach biomass estimate mimic those observed in roach density estimates (Figure 4).
- Over the period 2002 ~ 2010 slumps in biomass estimate (and density estimate) occur 3 times with a 4 year gap (2002, 2006 and 2010) suggesting an established cyclic pattern. Subsequent surveys after 2010 are unable to support this observation as scheduled surveys bridge the years when the expected troughs would occur. If these years are indeed troughs then by default the intervening years represent peaks.

- For the last 4 surveys (2010, 2013, 2016 & 2019) roach biomass has increased to the 2019 estimate of 236 grams / 100 m², not far short of its previous peak value in 2005.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	Av.
Trout	0	9	16	0	15	18	0	0	0	106	69	77	26
Dace	69	19	69	117	75	60	38	17	29	25	74	17	51
Perch	6	5	4	28	25	29	23	28	12	68	67	53	29
Pike	306	363	497	482	278	371	322	292	291	355	697	630	407
Roach	32	218	137	297	51	117	134	116	4	42	164	237	129
Chub	59	35	751	582	1000	459	1801	2602	571	1298	339	2224	977

Figure 5. Biomass estimates for 6 key species from 2002 ~ 2019 averaged across all sites. Dotted lines denote change from annual to 3 yearly survey schedule. NB Chub biomass plotted on second axis for clarity.

Dace

- Dace biomass estimate are relatively low (<120 grams / 100 m²) compared to their density. This indicates the presence of high numbers of smaller dace.
- In keeping with roach, dace biomass (and density) estimates peak in 2005 (Figure 4 & 5).
- The 2019 dace biomass estimate is the 2nd lowest estimate recorded from the 12 surveys; a significant drop compared to the previous 2016 survey result.
- Two significant peaks exist, the highest in 2005 (117 grams / 100 m²) and another in 2016 (73 grams / 100 m²). These peak values replicate peaks in density values for the same years (see figure 4).
- Dace biomass estimates mimic dace density estimates (Figures 4 & 5) suggesting a stable population structure

Pike

- Since 2004, pike biomass estimate is second only to that of chub. Prior to 2004, pike biomass estimate held apex position.
- Pike biomass estimate, like pike density estimate (Figure 4), shows long-term stability over the period 2002 to 2010.
- Pike biomass estimate increases after 2010 following the pattern observed in density estimate (Figure 4)
- There is a weak association between pike biomass estimate and roach biomass estimate, so too density estimates for both species.

Chub

- Chub biomass, in common with density, shows an increasing trend over the time period.

- Chub are the eminent species based on biomass estimate, since 2004 chub biomass is the largest of any species (note different scale for Chub in Figure 5).
- Chub biomass estimates vary significantly between surveys, but no decisive pattern is shown.
- Chub biomass estimate is strongly associated with chub density estimate (Figures 4 & 5).

Perch

- Perch biomass estimate prior to 2005 is below 7 grams / 100 m^2 across all sites. Since 2005, perch biomass estimate is consistently above 20 grams / 100 m^2, the only exception being in 2010.
- Perch biomass increased considerably in 2013 to 67.9 grams / 100 m^2 and has remained fairly steady to present day (2019).
- Perch numbers do increase as much, indicating and increase in the average size of perch.

Trout

- Trout biomass estimate peaks in 2013, representing the 3rd largest biomass for that year. Trout are recorded from 2 sites in that year; D/S Aylsham Bypass & D/S Plantation Bridge.
- In 2016, trout biomass estimates decreases by 30% compared to the 2013 peak, despite trout captures recorded from 4 of the 5 survey sites. In 2019 trout biomass estimate is once again 30% lower than the 2013 peak, but in this year trout are only recorded from the same 2 sites mentioned previously.
- Prior to 2013 trout biomass did not exceed 18 grams / 100 m^2

Comments / interpretation; long-term survey data.

Figures 4 & 5

Fish populations over the period show variable patterns. Chub and perch show clear increases and, to a lesser extent, trout and pike. Dace and roach fluctuate strongly. 2019 was a good year for chub and pike, in line with these trends, and also roach. Detailed comments are provided below for 2 species: chub and dace.

Across the years of surveys, 2005 is perhaps the best year with peaks in several species. 2010 looks like the worst year with poor results for several species, particularly roach. The reasons for these changes are not known although all species have had good results in the years since 2010.

Chub

Within the trend of increase, chub density and biomass estimates show a high degree of variability between surveys. Chub are caught almost exclusively at one site: D/S Buxton Mill. Consequently, results will reflect any changes in the population at D/S Buxton Mill bought about by food availability, habitat, lifestyle or climatic factors as well as factors such as survey timing. Observations suggest that chub use the area of river sampled below Buxton Mill to congregate prior to and after spawning on the gravel substrate available upstream at the mill (anglers obs). It is suggested that survey timing, coinciding with pre or post spawning activity due to flow and climatic conditions, account for the majority of the variability indicated.

To support this hypothesis chub biomass estimate recorded in 2016 is a useful example. Figure 5 shows that in 2016, chub biomass estimate drops below 400 grams / 100 m^2 (Figure 5) but density does not reduce as significantly. This is due to relatively low numbers of large fish being caught that year. This is thought to be due to the combination of a late survey and a warm spring. This meant the majority of the large adult chub involved in spawning would have dispersed downstream prior to survey (See comments D/S Buxton Mill Section). The early survey and cool spring of 2019 resulted in a high number of large adults in the survey site prior to dispersal, resulting in high density and biomass.

Dace

Dace, like trout, require ample quantities of high quality water along with an abundant food supply for survival and growth. Historic data indicate dace survive for 8+ years in the River Bure attaining specimen size. Reports by anglers of dace over 1 lb (450 grams) from discrete isolated populations in the River Bure are not out of the ordinary. These 2 statements indicate that the river Bure can and does support large adult dace. In further support, the number of trout aged 5+ indicates the River Bure contains water of

suitable quality and quantity for trout growth and survival. However, the relatively low biomass of dace indicates the surveys are dominated by small size dace.

Average dace density estimate in 2005 is the highest estimate for any species in the survey period (Figure 4). Abnormally high density estimates recorded at D/S Plantation Bridge, and higher than average density estimates both Lamas Hall and D/S Buxton Mill (Figures 12, 14 & 16) indicate that 2005 was a good year for dace recruitment at these 3 sites. Records also show high numbers of juvenile dace at these 3 sites for the 3 surveys prior to 2005. After 2006, numbers of juvenile dace recorded at these 3 sites decline significantly. Dace density estimates since 2006 are therefore almost wholly reliant on an ageing dace population derived from 3 of the 5 survey sites. The lack of juveniles recorded from 2006 compared to previous years indicates a recruitment "bottleneck" that may be due to limited spawning success and juvenile survival, or possibly a declining number of adult fish.

Site level results

The following section studies long-term trends in density and biomass estimates for key species at each site based on capture records from the site. Between Aylsham and Horstead a number of barriers exist. Most are the consequence of historic industrialisation, erected to enable water mills to operate, or to enable navigation up and down river. Whatever the reason for their existence, they impede the free movement of fish. Consequently survey sites are isolated above and below their locations and from each other; that said each survey site is representative of the isolated section of the river it sits in.
A summary of observations and findings is included for each site working in a downstream sequence.

D/S Aylsham Bypass

This is the furthest upstream site in the central section of the River Bure (see Figure 1 & Table 1). Hydro-morphology at this site differs from the other 4 sites. The top of the survey site lies at the junction where 2 branches of the river re-join. One branch is the original river course; the other represents a heavily modified channel; a legacy of the navigation to Aylsham Mill further upstream. The river is narrow here (less than 8 metres) unlike sites surveyed further downstream (mostly over 12 metres). Unlike sites downstream, the riverbed at this site undulates to create shallow and deep areas, in turn creating flow variations along with glides and runs within the site. For the most part the river is shallow. Incorporated in the site is a slight bend to the right when looking downstream.
Substrate consists of mixed sediments (gravels, sand & silt) along with chalk, marl and flint cobbles. Macrophytes are for the most part generalist species (submerged burr read, starwort) able to withstand grazing by the numerous crayfish that are present throughout the river. Riparian overhanging trees are not present at this site; shade and overhead cover are therefore limited.

Species	Total Number recorded	Number of fish over 99 mm FL
Stickleback	6	0
Trout	6	6
Bullhead	3	0
Dace	66	0
Eel	1	1
Gudgeon	156	8
Pike	2	2
Roach	97	3
Stone loach	23	0

Table 3: Species list and actual numbers recorded in 2019 survey at D/S Aylsham bypass site. Total number and number of fish over 99 mm FL shown. Survey area 1480 m^2 (185 m x 8 m).

Survey area at this site varied over the period considered; largest area surveyed is 1920 m^2. Since 2009 river dimensions appear stable and survey site is 185 metres long and 8 metres wide (1480 m^2).

Nine species are identified at this site in 2019 (Table 3) with 360 fish caught in total. Of the total, 340 are less than 99 mm FL.

Historic captures at this site include 3 additional species to those shown in Table 3 (lamprey, perch & tench).

Tench would not favour this site due to the predominant shallow, fast flowing hydraulic regime here. That said, their presence is recorded once in 2003; perhaps an indication of how hydro morphology has changed over time at this site. **Perch** last featured in a survey result from this site in 2010. Perch are recorded from 3 of the 12 surveys at this site. **Lamprey** are also recorded in 3 of the 12 surveys, recorded

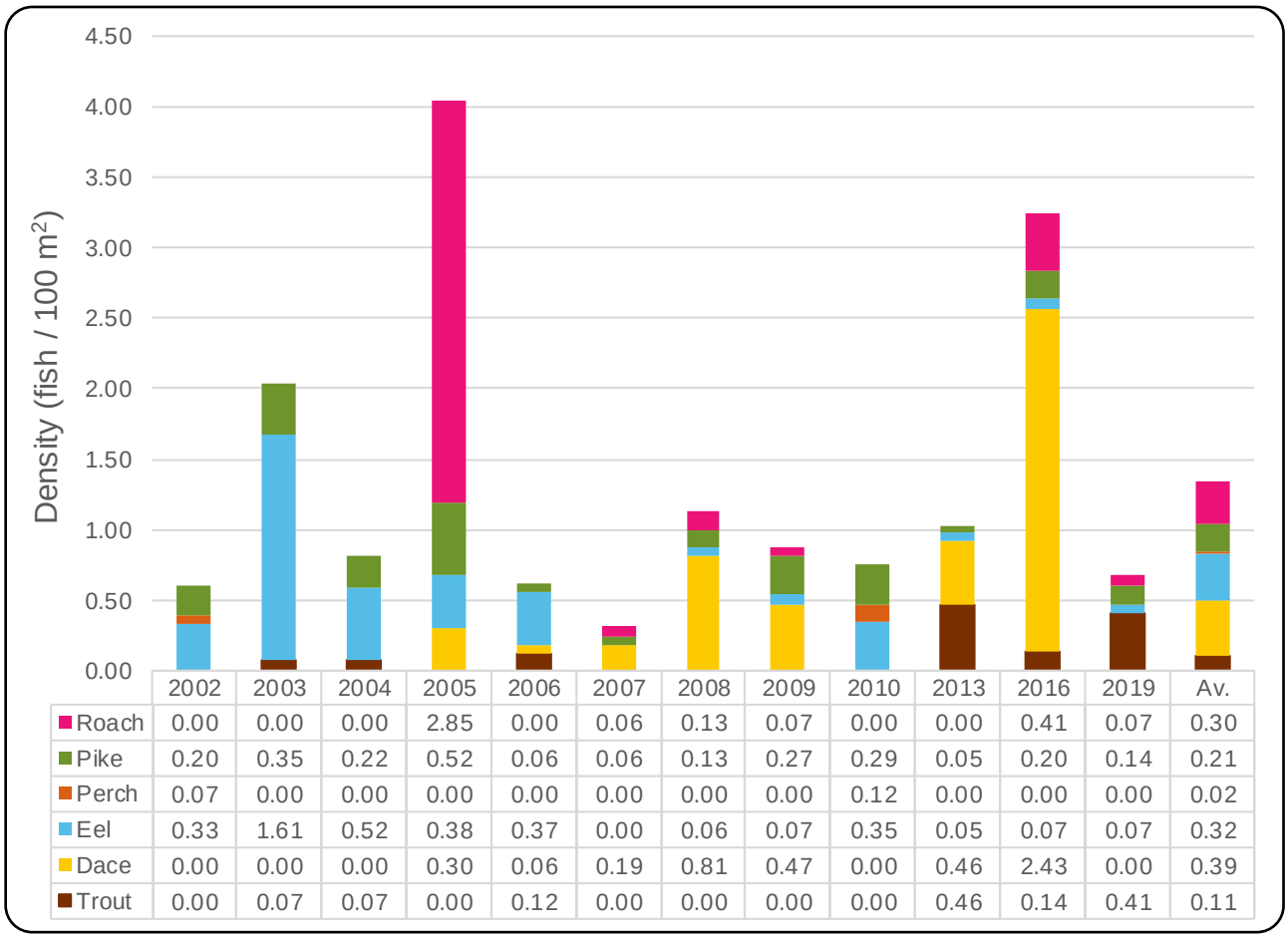
last in 2013. The shallow water, fast flows and lack of suitable sediment at this site prevent the creation of silt berms necessary for lamprey survival.

Bullhead exist at this site; 3 were caught in 2019. This is the only site on the central Bure that records them. They were first recorded at this site in 2013, being completely absent before that time, not just at this site but also throughout the whole river. As an indicator species, their presence and hoped for expansion will benefit the river over the long term.

Important indicator species are present at this site in 2019 (bullhead, eel, trout, stickleback and stone loach); species associated more with the upper reaches of a river known as the "trout" zone. In addition to the 5 species mentioned, dace, gudgeon, pike and roach are present, species often found in the "grayling" and "barbel" zones. The mix of species at this site illustrates that low gradient chalk streams can and do support a rich diversity of fish species that belie the low altitude and gradient of the river.

Long-term density at D/S Aylsham bypass survey site

Observations: long-term density (Figure 6)



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	Av.
Roach	0.00	0.00	0.00	2.85	0.00	0.06	0.13	0.07	0.00	0.00	0.41	0.07	0.30
Pike	0.20	0.35	0.22	0.52	0.06	0.06	0.13	0.27	0.29	0.05	0.20	0.14	0.21
Perch	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.02
Eel	0.33	1.61	0.52	0.38	0.37	0.00	0.06	0.07	0.35	0.05	0.07	0.07	0.32
Dace	0.00	0.00	0.00	0.30	0.06	0.19	0.81	0.47	0.00	0.46	2.43	0.00	0.39
Trout	0.00	0.07	0.07	0.00	0.12	0.00	0.00	0.00	0.00	0.46	0.14	0.41	0.11

Figure 6 Long-term density estimates for 6 species over 99 mm FL recorded from D/S Aylsham Bypass (2002 ~ 2019). Long-term average value shown for comparison. Note the change in survey frequency after 2010. Chub over 99 mm FL are not recorded at this site and are omitted for reasons of clarity.

Roach

- Roach over 99 mm FL are recorded in half of the 12 surveys. Densities are very variable at this site.
- Juvenile roach (below 99 mm FL) are recorded in 3 of the 12 surveys.
- In 2019 the vast majority of roach caught were juveniles – 94 of the 97 fish caught were under 99mm FL.
- The highest density estimate of roach over 99 mm FL is recorded in 2005 (2.9 fish / 100 m^2). The survey area in 2005 was 1335 m^2, significantly less than any other survey.
- Roach density estimate in 2005 is the highest of any species in any survey.

Dace

- Table 3 indicates 66 dace captured in 2019; none are over 99 mm FL. C&S estimates suggest that 121 juvenile dace are present at this site in 2019 based on the depletion rate evident at the time of survey.
- Dace over 99 mm FL occur in 7 of the 12 surveys.
- The highest dace density estimate (2.43 fish / 100 m^2) reported in 2016, is the second highest density estimate for any species in any survey.
- Dace density is highly variable during this period; the 2016 peak value is recorded just 6 years after no dace over 99mm FL were caught in 2010.

Pike

- Pike are represented in all 12 surveys
- The 2019 pike density estimate is a quarter of the peak value recorded in 2005: 0.52 fish / 100 m^2 and 30% lower than the long-term average value of 0.2 fish / 100 m^2
- No definite cyclic pattern indicating good spawning or recruitment years is evident in pike density estimates over the scrutinised period

Trout

- Trout are represented in 6 of the 12 surveys; the 3 highest trout density estimates occur in 2013, 16 & 19
- The 2019 trout density estimate is the second highest estimate recorded at this site and is four times the long-term average of 0.11 fish / 100 m^2
- Highest density estimate is recorded in 2013: 0.46 fish / 100 m^2

Chub

- There are no chub captured from this site; adult or juvenile for the survey period (2002 ~ 2019)

Long-term biomass at D/S Aylsham Bypass survey site

Observations: long-term biomass (figure 7)

Roach

- Peak roach biomass estimates mirror density estimates (figure 6) with a peak in 2005
- The 2019 roach biomass estimate is based on the capture of 3 roach over 99 mm FL: 1.4 grams / 100 m^2. The lowest estimate of any survey recording roach over 99 mm FL.

Dace

- Dace biomass estimates mimic the pattern evident in density estimate (figure 6)
- 66 dace are captured in 2019, all are juvenile. Biomass estimate in this report is based on fish over 99 mm FL
- Peaks in dace biomass occur in 2008 and 2016. Were this representative of a pattern the next peak would occur in 2024.

Pike

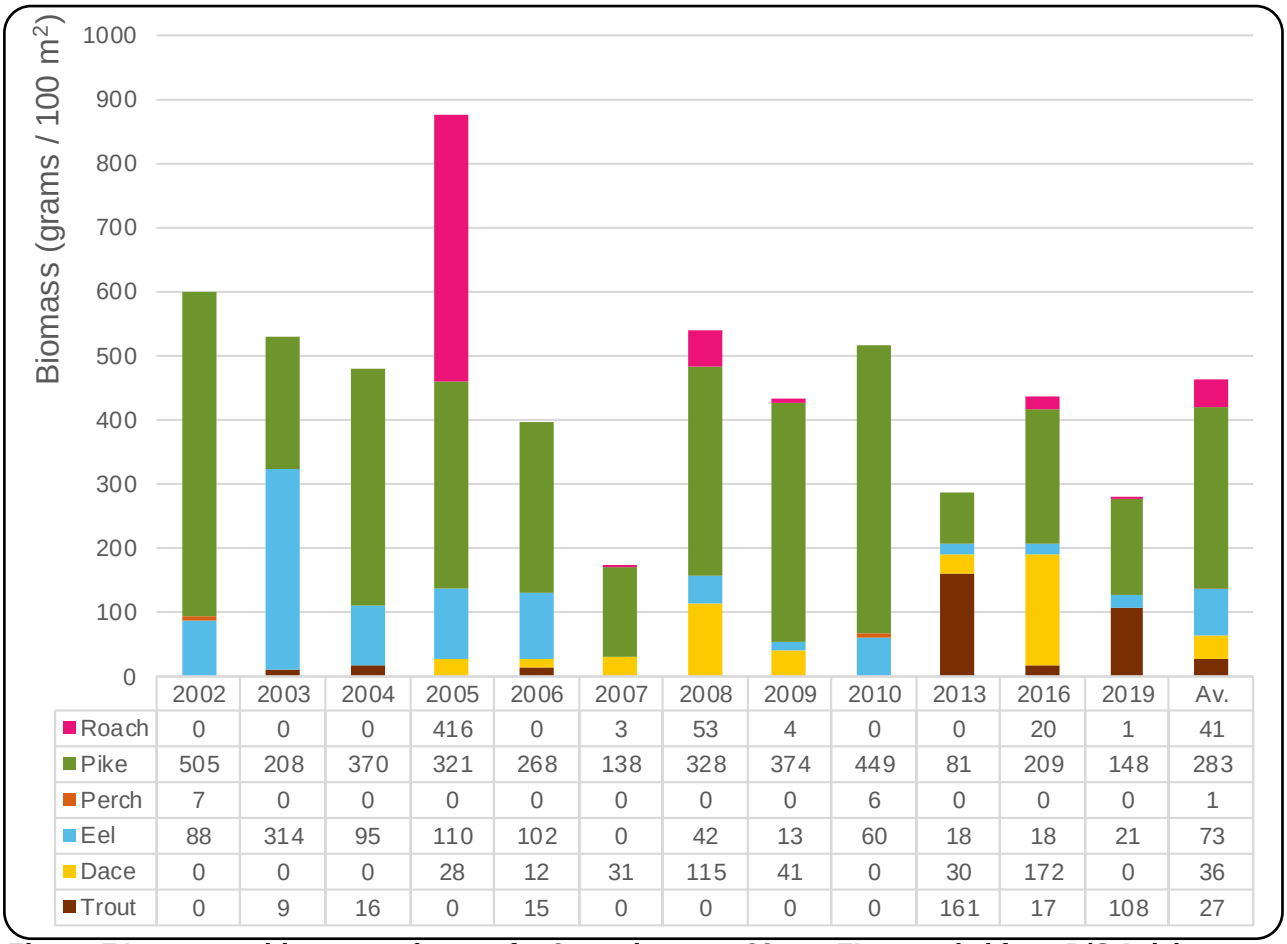
- Pike over 99 mm FL are recorded in all surveys
- For 9 of the 12 surveys pike biomass accounts for 60 to 89% of the total biomass
- Pike biomass estimate in 2019 is the third lowest recorded.
- Peak pike biomass estimate occurs in 2003; peak pike density estimate occurs in 2005

Trout

- The second highest peak in trout biomass estimate was recorded in 2019: 108 grams / 100 $m^{2,}$, well above the long-term average.
- The highest biomass estimate, recorded in 2013, is 160 grams / 100 m^2. This is a higher biomass estimate than that of pike for that year.

Eel

- In 11 of the 12 surveys, eel over 99 mm are present
- Eel biomass estimate in 2003 is 1.5 times greater than that of pike



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	Av.
Roach	0	0	0	416	0	3	53	4	0	0	20	1	41
Pike	505	208	370	321	268	138	328	374	449	81	209	148	283
Perch	7	0	0	0	0	0	0	0	6	0	0	0	1
Eel	88	314	95	110	102	0	42	13	60	18	18	21	73
Dace	0	0	0	28	12	31	115	41	0	30	172	0	36
Trout	0	9	16	0	15	0	0	0	0	161	17	108	27

Figure 7 Long-term biomass estimates for 6 species over 99 mm FL recorded from D/S Aylsham Bypass (2002 ~ 2019). Long-term average value shown for comparison. Note the change in survey frequency after 2010. Chub over 99 mm FL are not recorded at this site and are omitted for clarity.

Comments / interpretation

The number of **roach** captured at this site is highly variable but mostly low. This indicates this site lacks suitable habitat for both adult and juvenile roach and the high number of adult roach captured in 2005 may not be residents of the site. The lack of year on year recruitment (sporadic juvenile captures at the site) and subsequent minimal numbers of adult captures point towards the 2005 captures as a pre or post spawning aggregation.

That said, in personal conversation with the landowner residing next to the river, another reason for the high number of roach is offered. The landowner stated they regularly feed the fish in the river. Food, introduced at the upstream limit of this survey site, could attract and keep fish in the area, however, it is likely that all species would benefit rather than just roach. The survey results show that pike and roach density estimates peak in 2005 but trout, dace and perch density estimates do not.

Analysis of density estimates (figure 6, data table) shows little or no correlation between pike density estimate and density estimates of other species. This suggests pike predate on all species present at the survey site possibly along with other species such as large individuals of invasive crayfish known to have a long-term presence at the site. Pike density and biomass have different trends of highs and lows, suggestion the age structure of the individuals captured varies. For example the relatively high density and low biomass in 2003 suggests predominantly small individuals whereas the reverse was true in 2010 (low density; high biomass), indicating capture of fewer but large individuals.

Pike captures have been relatively low in the last 3 surveys. This may indicate the site is becoming less suitable for them compared with past years, possibly as the river self narrows and becomes faster flowing.

The presence of trout at this site has increased in recent years with the best 2 years occurring in the last 3 surveys. This suggest improvements in quantity and quality of water at the site. In addition the habitat changes which disadvantage pike would favour trout.

Trout density and biomass estimates at this site show negative correlations with those of pike. This correlation suggests that when trout are present in high numbers pike are not and vice versa (density correlation: - 0.44 & biomass correlation: - 0.64). These correlation values are in keeping with findings in the trout and pike populations of the River Wensum (see Wensum report 2019) and are further supported by the almost total absence of pike in the trout dominated River Glaven (see Glaven report 2018) and river Stiffkey (see Stiffkey report 2017).

Scale readings from the largest trout (452 mm FL) caught in 2013 indicates an age of 5+ (i.e. 5 growing seasons) and show very fast growth rate in the first 2 seasons. Scale readings from smaller individuals caught at this site indicate much slower growth rate in the first 2 ~ 3 seasons. This suggests the largest fish caught is a stocked fish (stocked trout are present upstream) and those displaying slow growth rates in their early years represent natural recruitment to the population.

Dace were absent at this site prior to 2005 and are highly variable since then e.g. a large peak in 2016 and absent in 2019 (although large numbers of juveniles were present). Probably relatively little can be read into results from individual years but they may be influenced by the same factors as roach. The weak trend of increase may again be due to better flow speeds in this section recently.

U/S Oxnead Bridge

Survey site characteristics

Image 2. Aerial view of survey site showing Oxnead Road Bridge: river channel and hard standing area for cut weed removal. River flow is from left to right, note the reduced width under the Road Bridge and subsequent pool formed downstream

This survey site lies just above Oxnead bridge, in fact the bottom net spans the river at the base of the bridge. This survey site lies between Aylsham Bypass and Plantation Bridge (figure 2 & table1). Mill structures up and down stream of this site isolate this site from those above and below it. Figure 1 (frontispiece) shows the view *downstream* from Oxnead road bridge towards Oxnead Mill.

This site incorporates a left hand bend in an otherwise straight channel. The 14-metre wide channel is for the most part of uniform cross section and perched above the flood plain. Little variation in depth is apparent within the river.

In keeping with other survey sites in the central section of the river, refuge habitat for fish in times of flood is scant, provided mainly by eddies formed behind collapsed bankside material.
Deep silt smothers most of the bed, but occasional gravel and sand patches are visible where higher flow velocity prevents finer sediment from settling. Sediment ingress caused by cattle poaching is evident in many places along the riverbank.

Limited macrophyte species are present. Established water lily beds exist in the slow flows along water margins while submerged fronds of bur reed and occasional starwort sway in the gentle mid river flows associated with this channel form. Marginal rushes and macrophytes encroach the open water in the upstream area of the survey site (top left, image 2). Two established willow trees grow on the left hand

bank of the river. Their overhanging branches provide limited shade and habitat while trailing roots provide further in-stream marginal habitat.
The bridge structure significantly reduces the width of the river underneath it, therefore river pace increases. The increased flow velocity under the bridge creates a pool feature immediately downstream of the bridge. Although not seen in 2018-9 (pers. Obs.), high numbers of adult roach and dace are usually evident below the bridge, holding station and feeding in the enhanced flow and on occasion gliding into the slack water at the sides of the pool. However, this feature is outside the survey site.

Situated 50 metres upstream of the road bridge on the right hand bank looking downstream, a hard-standing area exists (bottom right, image 2). During weed cutting operations, cut weed from upstream accumulates on a boom tied across the river at this point. The accumulated weed once removed is stored on the hard-standing area prior to disposal.

Ample evidence exists to indicate that signal crayfish inhabit this section of the river: holes in the steep soft clay banks, discarded shells and half-eaten carcasses to name a few. They grow large are abundant.

Survey area has altered over time. Maximum area surveyed is 3210 m^2. For the last 4 surveys the channel has stabilised creating a survey area of 2310 m^2. Between 2002 ~ 2010 annual surveys took place at this site. Since 2010, scheduled surveys take place every 3 years.

2019 survey results

Species	Total Number recorded	Number of fish over 99 mm FL
Eel	2	2
Gudgeon	33	2
Perch	1	1
Pike	20	20
Roach	18	0
Stone loach	3	0

Table 4: Species list and captures recorded in 2019 survey at U/S Oxnead Bridge site. Total number and number of fish over 99 mm FL shown. Survey area 2310 m^2 (165 m x 14 m).

Table 4 indicates the catch results for 2019. It shows 6 species of fish are present at the time of survey and a total of 77 fish were caught. Twenty-five of the 77 fish caught are over 99 mm FL. In previous surveys trout and dace have also featured in captures at this site.

All of the pike recorded in 2019 are over 99 mm FL. This is not surprising due to their body shape. Scrutiny of the data reveals over 50% (11) are below 300 mm FL. This indicates these 11 fish to be less than a year old. Of the 33 gudgeon recorded at this site in 2019, 24 are less than 60 mm FL; indicating 72% are less than 2 years of age. Both the total number and particularly number of fish below 60 mm FL are underestimates due to the way the survey method works.

The low number of fish over 99 mm FL caught in 2019 is not in keeping with long term density estimates at this site (figure 8). In 2018 (a year prior to this survey) a control gate at Oxnead Mill, opened fully in response to predicted high flows and remained jammed open for a couple of days. The resultant drop in water level and increased flow immediately upstream of Oxnead Mill removed the majority of marginal flood refuges and washed the majority of the fish present downstream. This is reflected in the low number of fish caught in this survey. The presence of juveniles indicates the few remaining adults have been able to spawn successfully. However the previous range of year classes of roach and dace are severely restricted or absent from the 2019 surveys at this site (figure 8 & 9).

Long-term density at U/S Oxnead Bridge survey site

Observations: long-term density (figure 8)

Of the 6 species considered over the 17 year period, eel, dace and roach account for the biggest share of overall fish density at this site. After 2006, eel density estimates reflect the national decline in eel populations and, as a result, they lose the prime position they held within overall fish density at this site. Roach and, to a lesser degree, dace continue to account for the lion's share of overall fish density in most surveys (figure 10). Both species are more numerous than at the D/S Alysham site but are again variable from year to year. The pattern of variability is not the same for both species. There is some evidence that

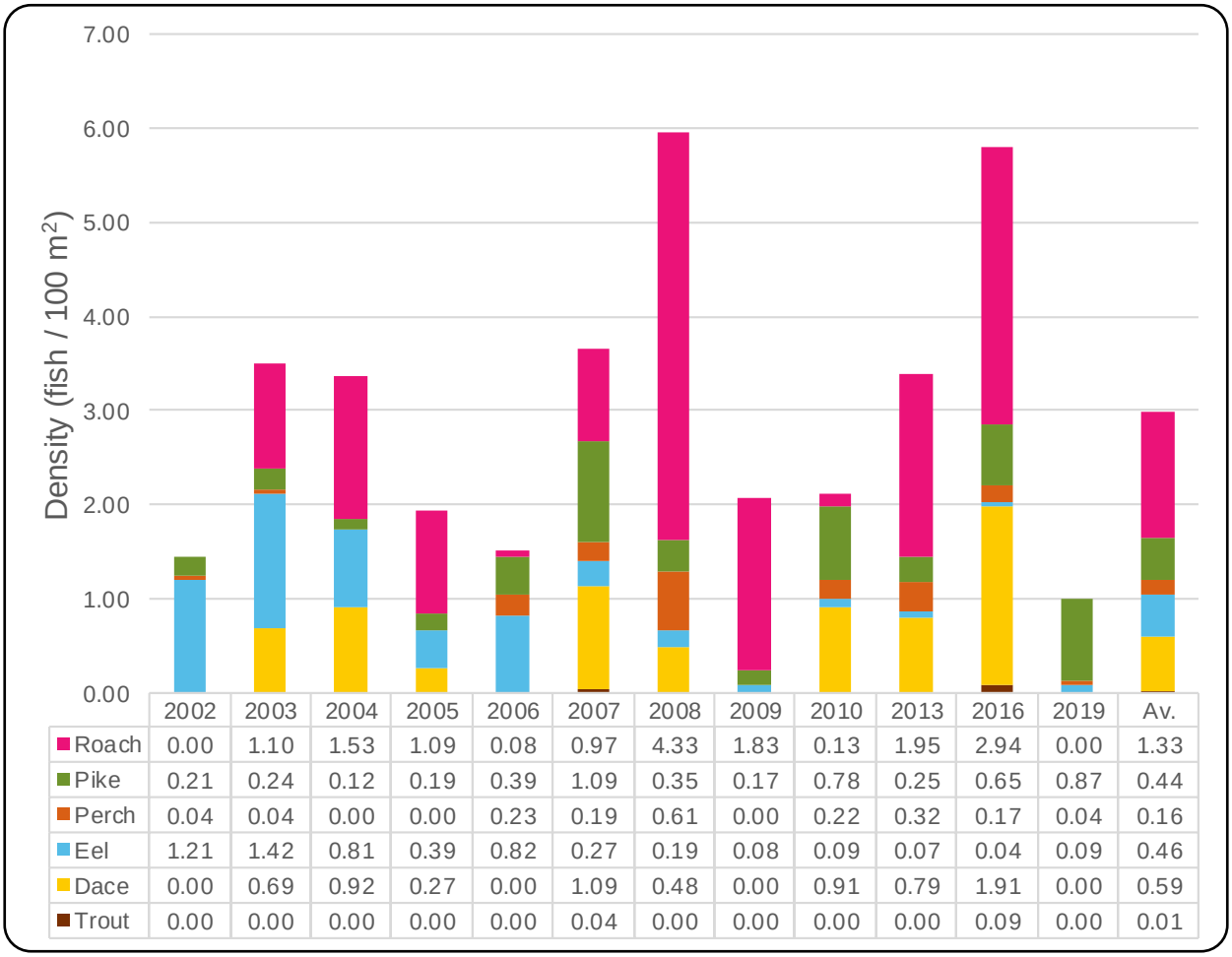
high catches of adult dace occur following a year when high number of juveniles were caught e.g. 2007 and 2010 both followed surveys with plenty of juvenile dace.

That said, it is of concern to see the sudden decline in both **roach** and **dace** density estimates at this site in 2019. The problem with the operation of Oxnead Mill gates has been described above and is at least a contributor factor in the population declines in 2019. A similar problem could be the cause of previous simultaneous declines of both species in 2002 and 2006. Alternatively it could be due to natural population dynamics or over-zealous channel clearance.

Pike density estimate over the 18-year survey period never falls to zero and shows some evidence of a rising trend over the long term. This highlights that despite sudden declines in prey species (see previous comments), pike are able to maintain their presence, exploiting alternative food sources to do so (juvenile pike, signal crayfish, waterfowl, etc). Pike body shape and their rapid initial growth from birth may also contribute to their contiguous presence at this site. Juvenile pike can attain a length over 99 mm FL in less than a season; this report analyses fish over 99 mm FL.

Perch are not abundant at this site. Although recorded in 9 of the 12 surveys, perch density estimate peaks in 2008 at 0.6 fish / 100 m^2; except for trout, this peak estimate is the lowest of any species at this site. Reasons are likely to include the lack of in-stream and riparian habitat. The high number of juvenile prey species caught in 2019 and in previous surveys indicate an ample quantity of suitable prey available for perch of all sizes. The flush through caused by opening the mill gates in 2018 may have affected this species too. Hopefully results in 2022 should reflect growth and recruitment following the 2019 low numbers.

As with the D/S Alysham Bypass site, no **chub** are recorded at Oxnead Bridge in any year.



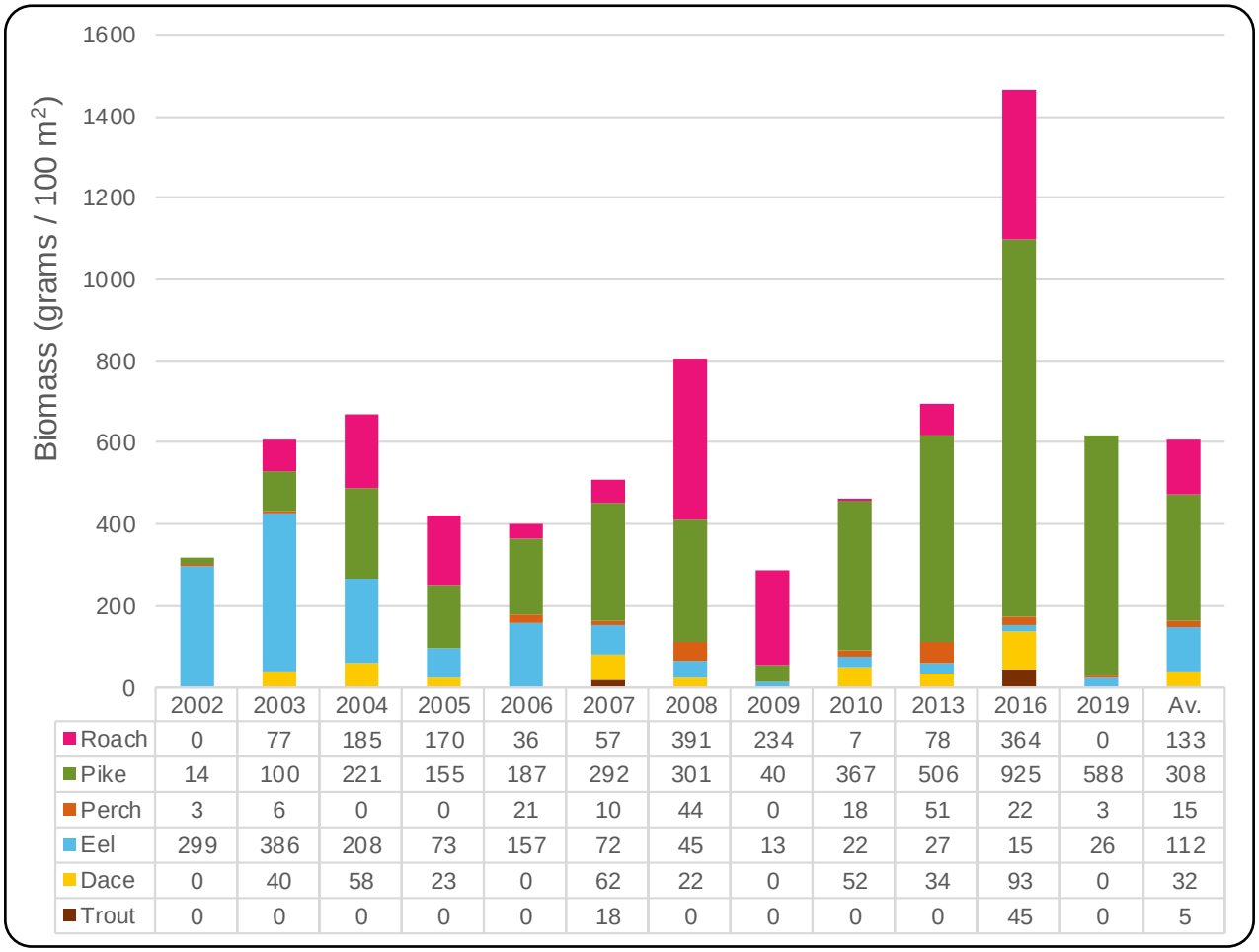
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	Av.
Roach	0.00	1.10	1.53	1.09	0.08	0.97	4.33	1.83	0.13	1.95	2.94	0.00	1.33
Pike	0.21	0.24	0.12	0.19	0.39	1.09	0.35	0.17	0.78	0.25	0.65	0.87	0.44
Perch	0.04	0.04	0.00	0.00	0.23	0.19	0.61	0.00	0.22	0.32	0.17	0.04	0.16
Eel	1.21	1.42	0.81	0.39	0.82	0.27	0.19	0.08	0.09	0.07	0.04	0.09	0.46
Dace	0.00	0.69	0.92	0.27	0.00	1.09	0.48	0.00	0.91	0.79	1.91	0.00	0.59
Trout	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.09	0.00	0.01

Figure 8 Long-term density estimates 2003 ~ 2019 for 6 key species over 99 mm FL at U/S Oxnead Bridge survey site. Note change to survey schedule after 2010.

Long-term biomass at U/S Oxnead Bridge survey site

Observations: long-term biomass (figure 9)

Eel density estimate and biomass estimates (figures 8 & 9) reflect the known, national and international decline in the species. That said, the average weight of each eel seems to be increasing: biomass in the 2002 ~ 2009 period was 159 ~ 270 grams / individual while in the 2010 ~ 2019 period was 255 ~ 375 grams/individual. This suggests eels can and do grow here, but little if any recruitment to the eel population has occurred over the survey period at this site.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	Av.
Roach	0	77	185	170	36	57	391	234	7	78	364	0	133
Pike	14	100	221	155	187	292	301	40	367	506	925	588	308
Perch	3	6	0	0	21	10	44	0	18	51	22	3	15
Eel	299	386	208	73	157	72	45	13	22	27	15	26	112
Dace	0	40	58	23	0	62	22	0	52	34	93	0	32
Trout	0	0	0	0	0	18	0	0	0	0	45	0	5

Figure 9 Long-term biomass estimates 2003 ~ 2019 for 5 key species over 99 mm FL at U/S Oxnead Bridge survey site

Apart from 2002 & 2003 when eel biomass is high, **pike** generally represent the primary biomass at this site. Pike biomass estimate is the highest biomass for 7 of the surveys and, as with density, seems to be increasing. Scale readings indicate growth rate is above average for pike in the Bure and that some individuals are over 10 years of age. This combination means older pike are of specimen size and therefore sought by anglers. Angling catch reports support this with numerous double figure pike captured from this section of river over the years. The stable pike density estimates (figure 10) and consistent survey captures suggest this will be the case for many years to come. This is the case in 2019 as well – they do not seem to have been affected by the drawdown at Oxnead Mill. This is not surprising as these large powerful swimmers would be able to hold station and swim against the rapid flow caused by the drawdown.

Roach biomass estimates exceed those of pike in 2005, 2008 & 2009 when large numbers of adult roach were caught. This is unusual. In the absence of chub, pike usually represent the dominant biomass in most Norfolk rivers (e.g. see 2019 Wensum report). Pike density and biomass estimates were particularly low in 2009; only 4 were caught, all relatively small (3 less than 250 mm FL). The reason is not known but biomass estimates have been relatively high in every survey since.

Trout seldom feature in capture results at this site due to the unsuitable habitat. However, a juvenile trout (48 mm FL) caught at this site in 2010 indicates a naturally spawned fish. The lack of suitable spawning substrate at the site suggests it may have migrated or been washed downstream. Regular natural trout recruitment occurs upstream (see Upper Bure report 2016).

Overall, the 2019 results are among the worst this site has provided since 2002. Density estimates for the majority of species at the site are significantly lower than previous years (figure 8) and in some cases, expected species are absent. Were it not for the presence of large pike in the catch results, biomass would be very low too (figure 9). The main reason is thought to be the loss of fish during drawdown caused by opening Oxnead Mill gates. The 2019 catch represents spawning success of the fish large enough to resist wash through: i.e. adults of species such as gudgeon, roach, dace and perch.

D/S Plantation Bridge

Survey site characteristics

This site is less than 1km downstream of U/S Oxnead Bridge site. Oxnead Mill is 600 metres upstream of this site and restricts fish migration between the 2 sites. Although now residential, the gates at Oxnead Mill are still in use and control water levels up and downstream. There are numerous similarities between this site and upstream Oxnead Bridge site. Both are heavily modified channels, both influenced by bridge structures and both are disconnected from the floodplain on one bank.

With the exception of the pool downstream of the simple bridge, width is uniform for 80% of the survey length. The river is over deep for its width along the majority of the survey site and during summer dense weed beds provide ample places for fish to hide, at the same time helping dissipate the electric field. Consequently, achieving effective catch depletion of the fish species at this site is not always straightforward. Flow regime is mainly laminar and uniform, apart from near the bridge where flow accelerates under the bridge, creating associated hydraulic features (glides, creases & eddies). Dace and roach often hold station and feed below the bridge in the increased flow (pers obs). Occasionally trout are visible too.
The pool is deep with depths to 4 metres in places. At the tail of the pool the depth shallows up to an almost uniform depth of 2~ 2.5 metres across the river and for the remainder of the site downstream.

Image 3 **Looking upstream and across "Plantation pool" at D/S Plantation Bridge site. Top stop net spans bridge supports towards background. Bottom net not shown. Survey includes pool created by high flows through bridge supports.**

In summer, clumps of water moss (Fontanalis sp.) cling to the submerged bricks, which abound immediately below the bridge, waving back and forth in the rapid flow. In the pool and further downstream, the long, submerged and floating leaves of burr reed rise to the surface to form dense and on occasion impenetrable mats. Substrate is predominately sand and silt, deposited by the mainly gentle laminar flow. When flow regime removes fine sediment, gravels are visible atop the underlying clay marl. Along the right hand bank and set back from the water's edge, tall poplar and lime trees are present. A frequently used, wide public footpath (a former towpath) follows the river between the poplar trees and the river edge. Occasional clumps of reed mace, arrow leaf and bulrush grow along the banks. No willow or similar species overhang the water or grow along either bank at the survey site.

Survey area has varied over time at this site ranging from 1350 m^2 to 2300 m^2. However, survey area has stabilised since 2013 at 1725 m^2: survey length: 150 m survey width: 11.5 m.

2019 survey results

Species	Total Number recorded	Number of fish over 99 mm FL
Dace	13	9
Eel	3	3
Gudgeon	22	0
lamprey	1	1
Perch	8	8
Pike	15	15
Roach	151	91
Trout	2	2
Totals	215	129

Table 5: Species list and captures recorded in 2019 survey at D/S Plantation Bridge site. Total number and number of fish over 99 mm FL shown. Survey area 1725 m^2 (150 m x 11.5 m).

A total of 215 fish, comprised of 8 species, are present in the 2019 survey. Of the total, 129 are greater than 99 mm FL (table 5). Previous captures at this site include a further 5 species: ruffe, stickleback, stone loach, tench and rudd. Stone loach and stickleback, although absent from the 2019 table, are in fact present at this site; several individuals of each species being observed at the time of survey.

Long-term density at D/S Plantation Bridge survey site

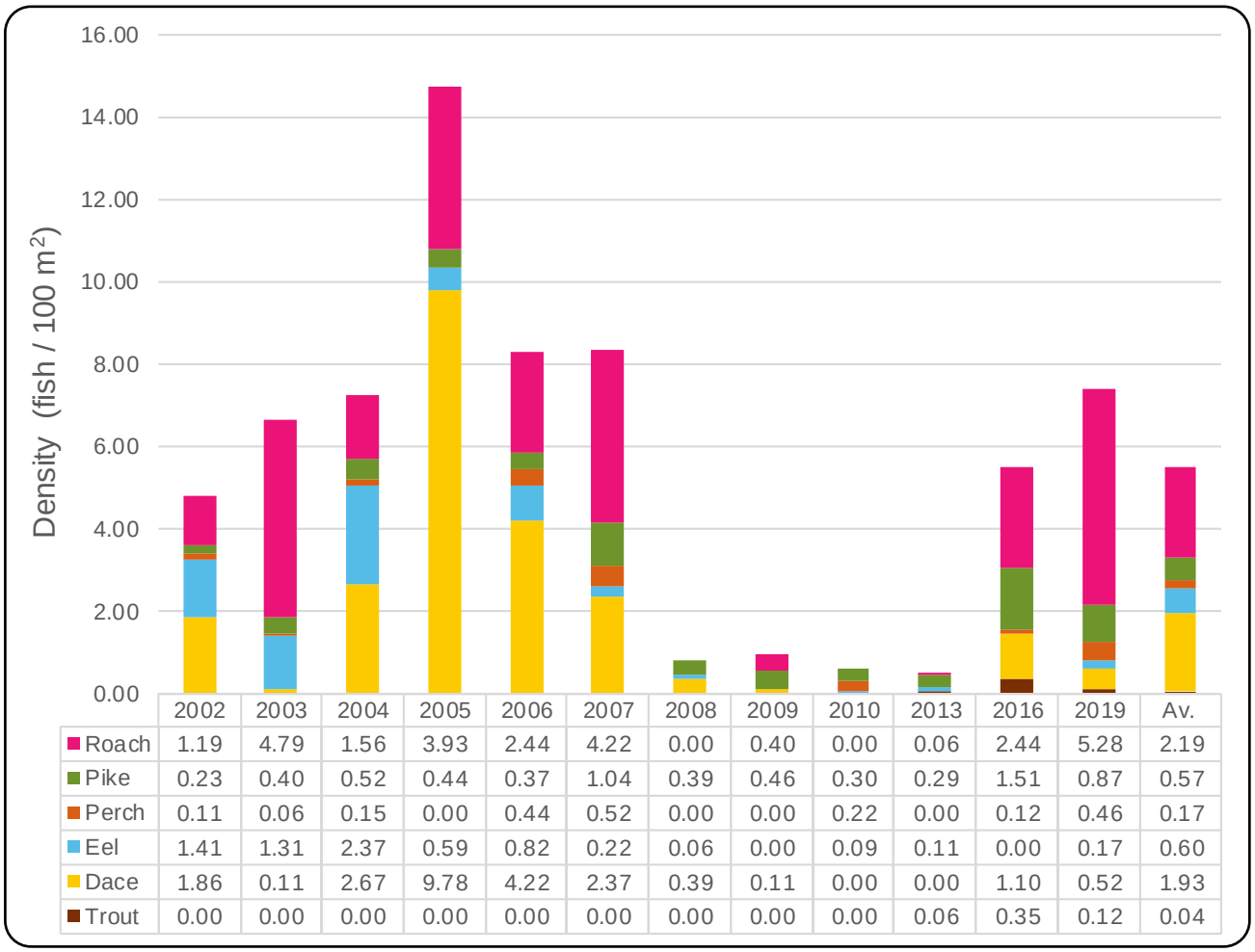
Observations: long-term density (figure 10)

Image 4: Trout caught by an angler from Oxnead pool, typical of the individuals caught in the surveys

Fly-fishing for trout is becoming more popular in the central section of the River Bure. The increased number and size of trout make fly-fishing viable and worthwhile (image 4). Putting that in context: no adult trout records exist for this site prior to 2013: juvenile trout are absent from all surveys. Since then, 9 trout over 99 mm FL are recorded: one in 2013, six in 2016 and two in 2019. All of the trout recorded are between 292 ~ 489 mm FL. Scale data suggests that naturally recruited trout of this size would likely be over 5 years old. Scale analysis of the largest 489 mm FL trout caught in 2013 indicates it is 3+ seasons old. Growth rings indicate rapid growth for the first 2 seasons of its life with much slower growth apparent for the last growth season. These readings strongly suggest this individual is a stocked fish. It is likely that a high proportion of the trout at this site originate from permitted stockings further upstream, although trout do spawn, grow and survive well in the upper reaches of the river.

The most notable feature of the long term record at this site is the very low numbers of fish caught in 2006 ~ 2013. This is of concern but the reasons may now be lost. That said, a number of physical factors could influence capture results to account for sudden changes in density estimates; one such factor is site characteristics. Deep, weedy sites, such as this one, are notoriously difficult to electric fish successfully and consistently. Consequently, survey results at such sites can be inconsistent. Further, experienced electric fishing staff acknowledge that fish, especially dace and roach, are adept at finding space in a river, space that fish use to evade capture. Deep water as found at this site increases the available space, whilst dense weed beds decrease the effects of the electric field on fish. These two factors result in higher numbers of fish, especially dace, evading capture. In contrast, the physical attributes of pike make them prone to capture. Their length renders them more susceptible to the effects of the electric field utilised during survey. In addition their physical shape reduces the available space for them to hide in. Both aspects increase their likelihood of capture. This goes some way to explain the apparent stability in pike density estimates compared to density estimates for the other species.

It is not known if such factors affected the 2006 ~ 2013 period more than other times. Reassuringly, density estimates for the same period at the upstream site, U/S Oxnead Bridge and downstream site, Lamas Hall (Figures 8 & 12) do not replicate the pattern indicated in Figure 10. Therefore the effect seems to be localised to this site. It is also good to see that numbers, particularly of roach, have bounced back in the 2 surveys since 2013.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	Av.
Roach	1.19	4.79	1.56	3.93	2.44	4.22	0.00	0.40	0.00	0.06	2.44	5.28	2.19
Pike	0.23	0.40	0.52	0.44	0.37	1.04	0.39	0.46	0.30	0.29	1.51	0.87	0.57
Perch	0.11	0.06	0.15	0.00	0.44	0.52	0.00	0.00	0.22	0.00	0.12	0.46	0.17
Eel	1.41	1.31	2.37	0.59	0.82	0.22	0.06	0.00	0.09	0.11	0.00	0.17	0.60
Dace	1.86	0.11	2.67	9.78	4.22	2.37	0.39	0.11	0.00	0.00	1.10	0.52	1.93
Trout	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.35	0.12	0.04

Figure 10 Long-term density estimates 2002 ~ 2019 for 6 key species over 99 mm FL at D/S Plantation Bridge survey site. Note change to survey schedule after 2010.

Roach currently show a strong presence at this site, being present in 10 of the 12 years surveyed and an increase again in average density on the previous upstream site. Roach density estimate has increased since 2013 to a peak in 2019: (5.3 fish / 100 m^2). Juvenile roach are also present in 10 of 12 surveys and are present even in years when adults are not. With 2 exceptions the actual number of juveniles is rarely high. Exceptions are 2006 and 2019 (28 & 60 individuals respectively).

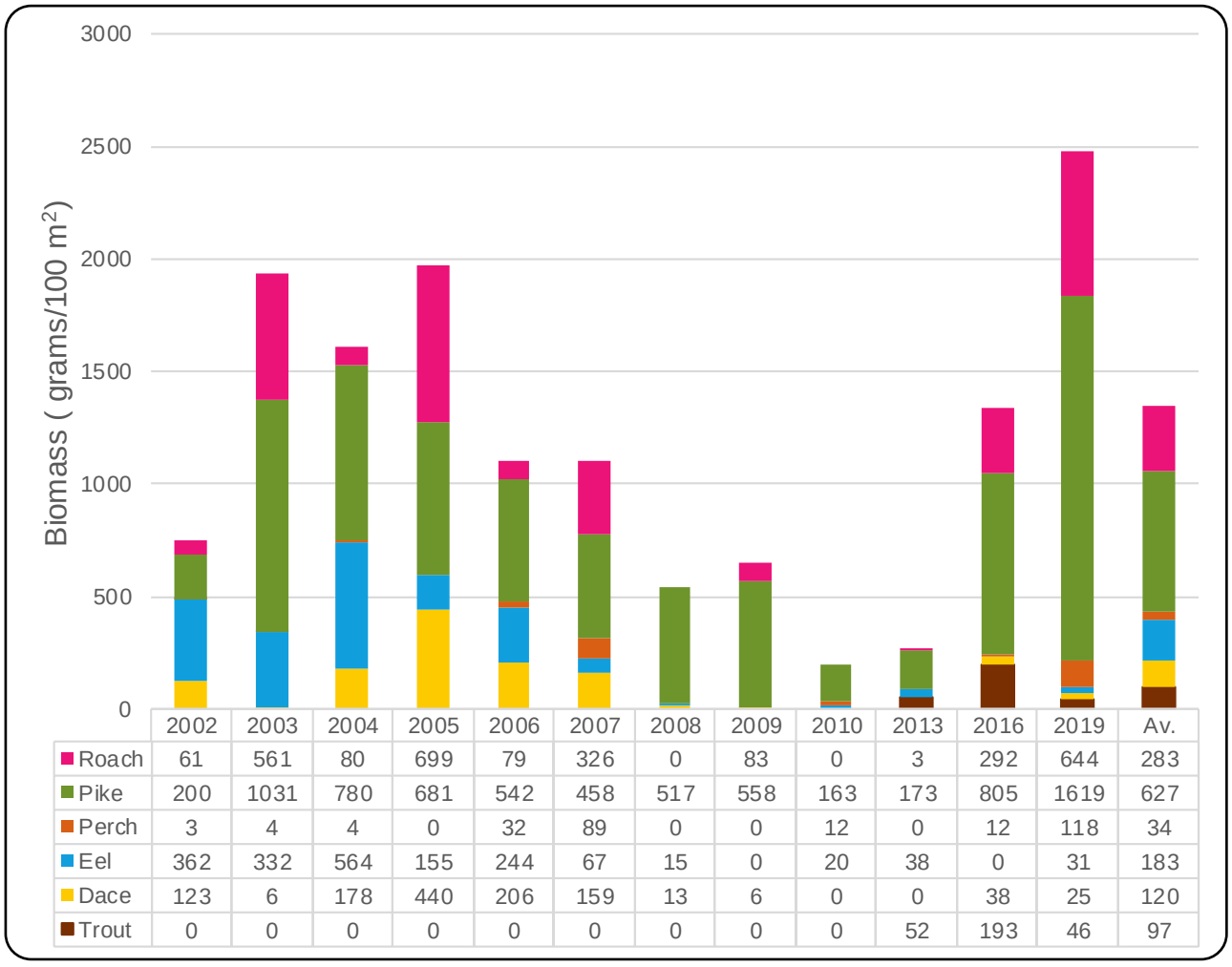
Adult **dace**, like roach, are present at this site in 10 of the 12 surveys, the absences also coinciding with the 4 survey low period. Dace density estimates vary from 0.1 fish / 100 m^2 (2003 & 2009) to 9.8 fish / 100 m^2 (2005). There is no consistent cyclical pattern to the fluctuations. **Perch** presence at this site is in keeping with previous sites: sporadic. Peak density, recorded in 2007 is 0.52 fish / 100 m^2. 2019 was also a relatively good year with 0.4 fish / 100 m^2.

Pike over 99 mm FL are present in all 12 surveys, since 2002 (data table, figure 12). Other than 2 peaks noted in 2007 and 2016, pike density estimates show stability over time varying by less than 20 % above or below a central value (0.4 fish / 100 m^2). The peaks mentioned in 2007 & 2016 exceed 1 fish / 100 m^2 (1.04 & 1.56 fish / 100 m^2 respectively). These are abrupt increases in density estimate and coincide with high numbers of smaller fish; possibly the consequence of successful spawning and recruitment to the population.

Long-term biomass at D/S Plantation Bridge survey site
Observations: long-term biomass estimates (figure 11)

Pike hold principle position for biomass estimate in all bar 1 of the 12 surveys. The average over this time period is about twice that of the 2 sites upstream. The peak estimate in 2019 of 1.62 kilogrammes (3lbs 9 ozs) per 100 m^2 is almost 3 times the average pike biomass estimate. Eel biomass estimate in 2002 exceeds that of pike by a factor of 1.8; the only species in any survey at this site to displace pike from principle position (data table, figure 13) and then only once, in 2002. Pike over 620 mm FL (2 kg : 4lbs 6ozs) are present in the capture records for every survey at this site.

Pike biomass estimate in 9 of the 12 surveys exceeds 450 grams / 100 m^2, a respectable biomass and one that reflects both density and size of pike at this site. The largest pike recorded from the 15 individuals caught at this site in 2019 weighed over 18 lbs; this is the largest fish caught in the 2019 surveys (table 2). Pike in excess of 20 lbs (9.1 kg) feature 5 times in the survey results at this site. Angling captures and survey data support the statement that pike thrive at this site.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	Av.
Roach	61	561	80	699	79	326	0	83	0	3	292	644	283
Pike	200	1031	780	681	542	458	517	558	163	173	805	1619	627
Perch	3	4	4	0	32	89	0	0	12	0	12	118	34
Eel	362	332	564	155	244	67	15	0	20	38	0	31	183
Dace	123	6	178	440	206	159	13	6	0	0	38	25	120
Trout	0	0	0	0	0	0	0	0	0	52	193	46	97

Figure 11 Long-term biomass estimates 2002 ~ 2019 for 6 key species over 99 mm FL at D/S Plantation Bridge survey site. Note change to survey schedule after 2010.

In 2019, **roach** provide the 2nd highest biomass estimate of the key species and is the 2nd highest roach biomass estimate across all 12 surveys (data table, figure 11). This reflects the high number of roach caught in 2019 and their average size.

As with density, both roach and dace biomass show wide fluctuations over the years with no obvious cyclical patterns. 2005 was a particularly good year for both species. The average over all years is highest at this site compared with those both above and below. Roach have recovered well from the 2008-13 low

period. **Dace** did particularly well in the 2004-7 period but less so in recent years. These results indicate that dace struggle to maintain their presence at this site. This is not surprising; both dace and trout require abundant, well oxygenated cool water of high quality to survive, often migrating to find suitable water conditions. Oxnead Mill and bypass weir, upstream of this site offer better conditions. Recent feedback from anglers on the bank indicate high numbers of dace and an increasing number of trout are present at Oxnead Mill (image 4).

Despite the limited flow regime and habitat available for them at D/S Plantation Bridge site, **trout** are present in surveys since 2013 (Figure 10 & 11). The 2nd highest trout biomass estimate in 2013 is remarkable because it derives from a single fish. This individual fish, measured at 498 mm FL and aged at 3+, shows all the signs of being a stocked fish rather than a sea trout. Sea trout scales indicate slow growth while in the river and very rapid growth while at sea, almost the exact opposite pattern to that seen in scale analysis of farmed stock fish. Sea trout are often seen by SCUBA divers around Horstead Mill; the tidal limit. To date sea trout have not been identified in fish surveys at this or any other site on the river. Trout density estimate in 2016 derives from 6 trout captured at the time of survey (Figure 10). The peak trout biomass estimate recorded in 2016 (Figure 11) indicates that these 6 trout are of high average size too.

Comments / Interpretation

The most notable feature of the long-term data set from D/S Plantation Bridge is the low numbers of fish caught during the 2008-2013 period. Biomass also showed reductions, only helped by the capture of a small number of large pike. Since then, happily, most populations have bounced back. This is particularly noticeable for roach that hit a high in terms of numbers and nearly equalled the highest biomass. The high number of roach in 2019 could represent additional recruitment to the population by fish washed downstream from the U/S Oxnead mill site because of the event described previously. Dace have done less well. The nature of the survey site, being wide and deep, and the abundant plant growth produces slow flows that favour roach more than dace. However, comments and observations by anglers indicate higher than usual numbers of dace are present in suitable habitat upstream of the survey site. This could also be a consequence of the upstream drawdown and subsequent wash through.

Pike have maintained a good presence throughout and done particularly well in the last 2 surveys. Perch have only ever been captured in low numbers and 2019 happened to be a relatively good year. Eel captures at this site, in common with so many others, have generally declined over time. This is in keeping with the global reduction in population levels.

A feature of particular interest is the appearance of trout at this site in the last 3 surveys whereas they had been absent before. As discussed, the majority are thought to be stocked fish moving down from further up river.

Lamas Hall

Survey site characteristics

Lamas Hall, 1.6 km upstream of Buxton Mill and a similar distance from D/S Plantation Bridge shares many of the geomorphological characteristics of D/S Plantation Bridge site. Both are in the same river reach and no barriers exist between the sites. Increased discharge is evident at Lamas Hall compared to D/S Plantation bridge due to the Kings Beck tributary joining the main river 300 metres upstream of the survey site on the left hand bank.

This site is almost straight for its 160 m length, of uniform width (15 m). It has a “U” shaped cross section and is mainly 2 metres deep. No overhanging trees exist on either bank. The right hand margin is steep dropping quickly to bed level. Sediment deposition creates isolated in-stream levees along the right hand side of the river and sweet reed grass extends from the bank across the intervening shallow water. Some cattle poaching is evident, mainly on the right hand bank. Burr reed is the most prolific in-stream macrophyte. Occasional yellow water lily flowers show on the water surface along with their characteristic “brandy bottle” fruits as the season progresses. Their large floating leaves provide limited shade while the submerged “cabbage” leaves provide refuge for juvenile fish. Survey area has changed over time at this

site from 3260 m^2 to the present 2432 m^2. Width has remained almost constant (15 ~ 16 m) however, survey length has reduced from 200 m to the present day 160 m.

Eleven of the 12 surveys scheduled at this site were completed. Data from the initial run of the 2009 survey is available; unfortunately, the remaining 2 runs scheduled in the 2009 survey did not take place. To avoid confusion, incomplete data from the 2009 survey are omitted.

2019 survey results

Species	Total Number recorded	Number of fish over 99 mm FL
Dace	8	2
Eel	8	8
Gudgeon	4	0
Perch	1	1
Pike	15	15
Roach	100	72
Stone Loach	6	0
Tench	1	1

Table 6: Species list and captures recorded in 2019 survey at Lamas Hall survey site. Total number and number of fish over 99 mm FL shown. Surveyed area 2432 m^2 (length 160m x width 15.2m)

In total 143 individual fish, comprising 8 different species, are present at Lamas Hall survey site in 2019. Of the total number, 99 are over 99 mm FL. Roach and pike are present at this site; roach especially in high numbers. This site provided the largest roach caught in the 2019 survey season at 268 mm FL: 400 grams (14 ozs). Of the 15 pike recorded in 2019 the largest measured 654 mm FL (2.5 kg: 5.5 lbs).
In previous surveys, 4 additional species contribute to the species assembly at this site: chub, ruffe, stickleback and trout.

Long-term density at Lamas Hall survey site

Observations: long-term density (figure 12)

Results are not presented for 2009 because only a single survey run was completed – the second run had to be abandoned due to a thunderstorm. This results in low confidence of the accuracy of population and biomass estimates that could be misleading.

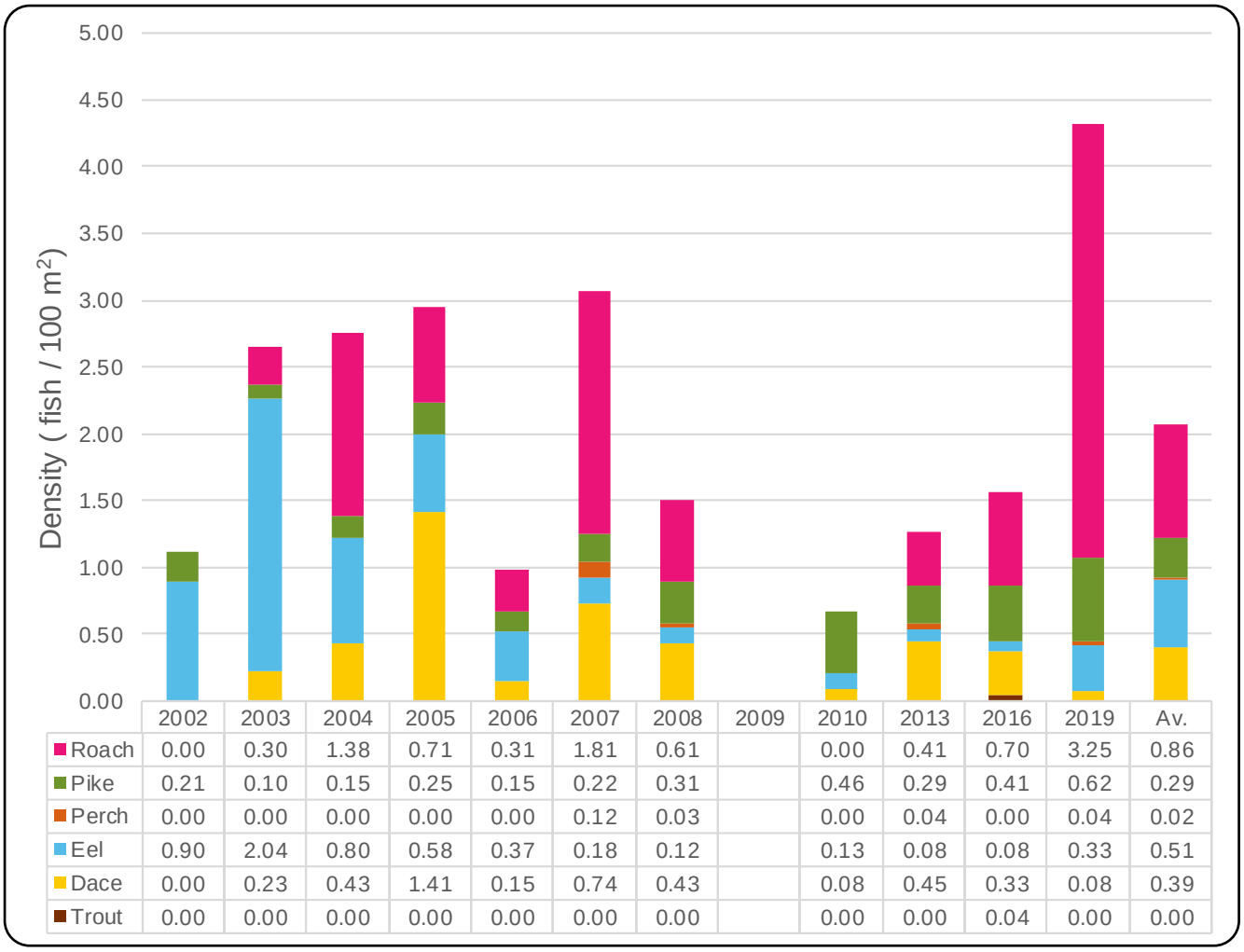
Pike are present in all surveys with a peak in 2019 at 0.62 fish / 100 m^2. Throughout the remaining 10 surveys, pike density estimate remains relatively stable (0.1 ~ 0.46 fish / 100 m^2). Pike density estimates (and biomass) include a mixture of juvenile and adult pike, this is due to their elongated body shape; pike over 1 years old are greater than 99 mm FL. Therefore, all pike caught feature in this report; unlike roach that can take up to 3 years to attain 99 mm FL. By way of example: of the 15 pike recorded in 2019, nine are less than 2 years old yet all pike caught feature in this report. As with Plantation Bridge, density peaks are usually caused by high numbers of juvenile fish.

At this site, a high proportion of juvenile pike are caught from the dense marginal vegetation; most of the larger individuals recorded tend to reside among weed in the main flow (pers obs.). The changing proportion of juvenile to adults at this site indicates successful spawning, growth and longevity ensuring recruitment and a stable population over time.

Adult **roach** are present in 9 of the 11 surveys (figure 12). In the remaining surveys (2002 & 2010) adult roach are absent from this site however juvenile roach are present, indicating roach are present at this site throughout the entire survey period. There is a highly significant correlation (R = 0.85) in roach density estimates at Lamas Hall and D/S Plantation Bridge across the survey period. This is no surprise as Lamas Hall and D/S Plantation Bridge sites are situated 1.6 km apart on the same section of river and no physical barriers exist to separate them. This means that both sites display similar patterns of peaks and troughs in density estimate over time. That said, roach density estimates at Lamas Hall are lower than D/S Plantation Bridge estimates for the

same survey period. No other sites display such a strong correlation for roach density.

At Lamas Hall, roach density estimate peaks in 2019: 3.3 fish / 100 m^2 which is over 3 times the site average density estimate (Figure 12) but approximately half that of the 2019 estimate obtained at D/S Plantation Bridge site (figure 10). For each of the 3 surveys conducted over 2010 to 2016 roach density estimates increase by 0.3 ~ 0.4 fish/100 m^2. The 2019 roach density estimate is a significant increase in comparison to the 3 previous surveys; and shows an almost four fold increase on the 2016 estimate. Combining adult and juvenile roach captures at the site prior to 2019 does not account for the sudden and significant increase in the 2019 roach density estimate.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	Av.
Roach	0.00	0.30	1.38	0.71	0.31	1.81	0.61		0.00	0.41	0.70	3.25	0.86
Pike	0.21	0.10	0.15	0.25	0.15	0.22	0.31		0.46	0.29	0.41	0.62	0.29
Perch	0.00	0.00	0.00	0.00	0.00	0.12	0.03		0.00	0.04	0.00	0.04	0.02
Eel	0.90	2.04	0.80	0.58	0.37	0.18	0.12		0.13	0.08	0.08	0.33	0.51
Dace	0.00	0.23	0.43	1.41	0.15	0.74	0.43		0.08	0.45	0.33	0.08	0.39
Trout	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.04	0.00	0.00

Figure 12 Long-term density estimates for 6 key species over 99 mm FL at Lamas Hall survey site. Note change to survey schedule after 2010.

Dace density estimate in 2019 (0.08 fish / 100 m^2) is the joint lowest estimate for the species across all surveys and considerably lower than that recorded in the 2 previous surveys in 2013 & 2016. Further, the 2019 dace density estimate is significantly below the long-term site average for the species and represents less than 2% of the total density recorded for the top 5 species. Dace density estimate peaks at this site in 2005; this reflects the peaks observed at other sites (Figures 10 & 8), suggesting exceptional spawning, survival and recruitment in the preceding years. As with roach (see previous comments) dace density estimates at Lammas Hall and D/S Plantation Bridge show a strong correlation of 0.8.

Chub make a scarce appearance in the catch records at this site: 3 chub recorded in 2004 and 2 chub present in 2005. For clarity, density estimates for this species in both years are omitted from

Figure 12 and the corresponding data table. Density estimates are 0.09 and 0.06 chub /100 m^2 respectively. Fork length measurements and analysis of scales removed from fish of similar size indicate these 5 individuals to be mature adult chub between 11 and 15 years of age. Adult chub such as these have circumnavigated Buxton Mill to reach this site. For whatever reason chub have not featured in surveys at this site before or since.

Perch captures indicate erratic presence at this site. They have only been caught in 4 of the 11 surveys; only trout and chub show less prevalence. Highest perch density occurs in 2007 (0.12 fish / 100 m^2) when 4 perch over 99 mm FL are recorded. Juvenile perch (under 99 mm FL) are absent from all surveys.

Pike are present in every survey; including 2009. The peak density estimate in 2019 is over twice the long-term average for this site (0.62 & 0.29 fish per 100 m^2 respectively)

Long-term biomass at Lamas Hall survey site

Observations: long-term biomass estimates (figure 13)

Trout are not common at this site as demonstrated by the single trout, captured in 2016, that provides the density and biomass estimates for the species across all surveys at Lamas Hall. Measured at 382 mm FL, this individual could represent a fish from upriver, migrating downstream or a returning sea trout. Numerous observations of sea trout below Horstead Mill, reported by anglers, provides evidence to support the presence of sea trout in the River Bure. However, no scales were removed at the time of capture so we can't say anything about its provenance.

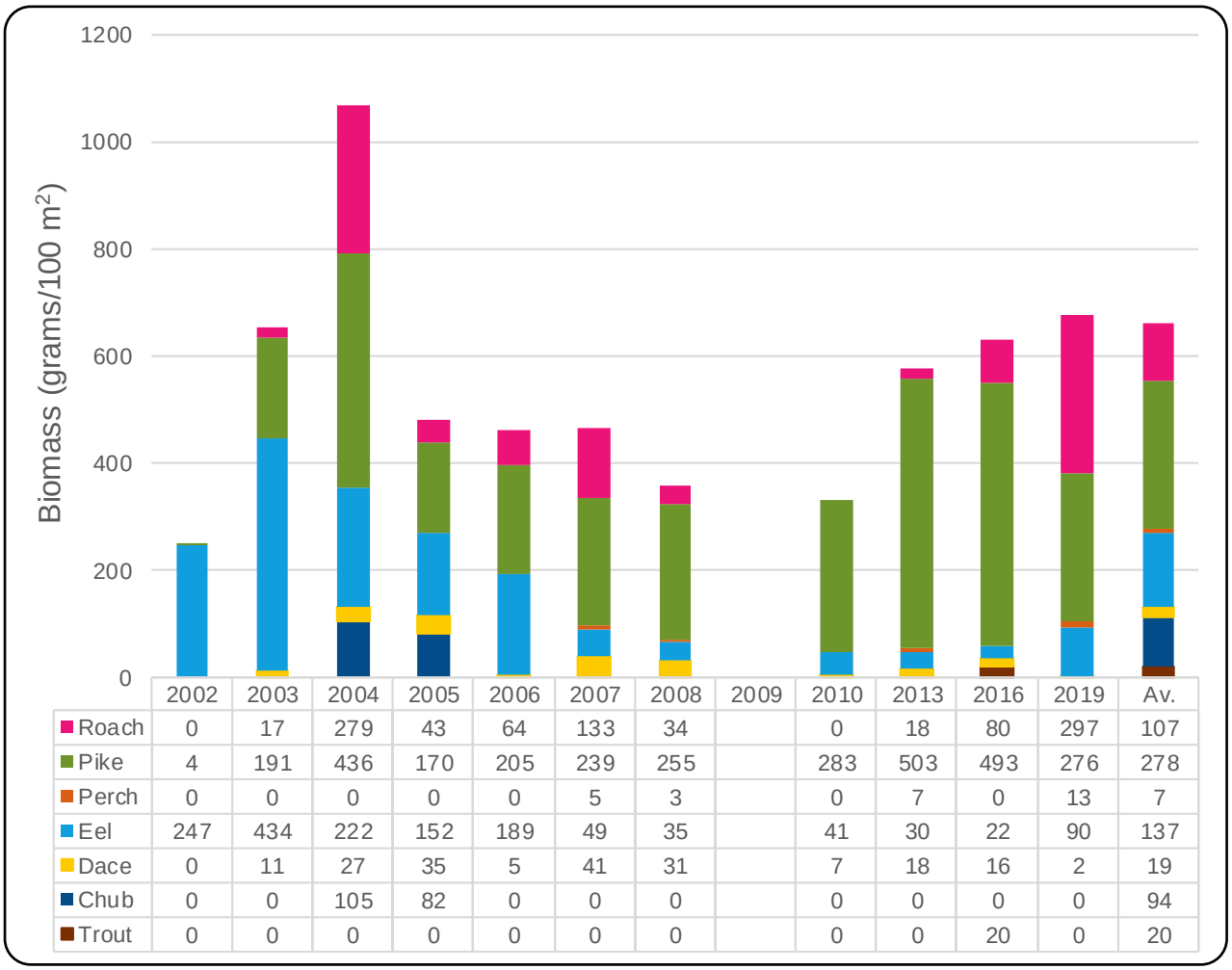
Roach biomass estimate peaks in 2019 in line with peak density estimate recorded in that year (Figures 12 & 13). Less pronounced peaks in roach biomass occur in 2004 and 2007 that reflect density estimates for the same years. Roach biomass estimates in the surveys immediately prior to the peaks noted in 2004 and 2019 are significantly lower: e.g. 2016, roach biomass estimate is 25% of the 2019 estimate while the 2003 estimate is less than 1% of the 2004 estimate. A 99% increase in roach biomass estimate in one year is difficult to account for using natural growth and recruitment characteristics. However, similar unexpected changes occur in 2005 at D/S Aylsham Bypass site, changes attributed to pre or post spawning aggregations of roach. The 2019 estimates could represent impacts of 2018 Oxnead Mill sluice event too. Roach over 2lbs + are recorded from this site in 3 of the 11 surveys, indicating suitable habitat and food supply are available for them to attain prize weights.

Dace biomass estimate in 2019 is significantly below the long-term site average, and represents less than 0.5% of the total biomass for the year. Although dace density estimates are respectable when compared to those of roach (Figure 13), dace biomass estimates are much lower, in the majority of surveys being less than 50% of the corresponding roach biomass estimates. Dace biomass estimates account for little of the overall site biomass; only perch display lower biomass estimates (Figure 13, data table). The low biomass estimates belie the importance of dace within the river. Dace rarely attain great weight in comparison to other species e.g. chub, pike, roach or perch, but survey records often show high numbers of dace between 100 & 180 mm FL with successive year classes and a slow but natural progression through to adulthood. Predatory species are most likely to benefit from the plentiful population of prey-sized individuals.
Scale analysis shows a select few dace live in the river Bure for over 8 years and attain weights in excess of 454 grams (1 lb). In one instance, a dace measuring 364 mm FL was recorded from the river. Based on EA National length weight metrics this fish could weigh in excess 1lbs 6ozs; an ounce over the British rod caught record for this species.

Perch density and biomass estimates reveal their highly vaiable presence at this site. Capture data show a complete absence of juvenile perch at this site in the 11 surveys. While biomass (and density) estimates derive from 7 adult perch recorded across the 11 surveys. Indeed perch biomass estimate in 2019 derives from an individual fish.

For whatever reason, perch do not inhabit this site permanently; the random nature of the data suggest the modest sized perch recorded are captured as they pass through this site on their patrols between areas of river more to their liking.

Since 2004 and until 2019, **pike** biomass estimates provide the prime share of total biomass at this site. In 2019 the exceptionally high roach density estimates noted (Figure13) provide correspondingly high roach biomass estimates that surpass pike biomass at this site. No doubt, the high number of pike recorded at this site in 2019 (Figure 13 & Table 6) will benefit from the shift in roach biomass recorded and return pike once more to prime position as the predator / prey relationship swings back into balance. The next scheduled survey should inform this.
In a high proportion of the surveys, specimen-sized pike contribute to the biomass estimates at this site. Over 20% of the 87 pike caught across all surveys at this site weight more than 2.3 kg (5lbs). Five attain a weight in excess of 9.1 kg (20 lbs). In addition, pike captures show successive year classes in each survey from 1+ juveniles through to adult fish over 10 years old.
Pike inhabit this site, thriving in the available habitat and on the prey species recorded here.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	Av.
Roach	0	17	279	43	64	133	34		0	18	80	297	107
Pike	4	191	436	170	205	239	255		283	503	493	276	278
Perch	0	0	0	0	0	5	3		0	7	0	13	7
Eel	247	434	222	152	189	49	35		41	30	22	90	137
Dace	0	11	27	35	5	41	31		7	18	16	2	19
Chub	0	0	105	82	0	0	0		0	0	0	0	94
Trout	0	0	0	0	0	0	0		0	0	20	0	20

Figure 13 Long-term biomass estimates for 6 key species over 99 mm FL at Lamas Hall survey site. Note change to survey schedule after 2010.

Comments / Interpretation

There are 8 year classes represented in the 100 **roach** caught at this site in 2019 (Table 6); ages range from 1+ through to 10+. The mixture of year classes and the number of individuals representing each year class indicate long-term presence of roach at this site with spawning success, survival, growth and recruitment evident. That said, representatives from 2 year classes are missing from the 2019 captures indicating poor spawning and recruitment in those years.

Adult roach are absent from this site in 2010 but are present in 2007, 2008 and in the partial survey records for 2009. Adult roach are absent in 2008 and 2010 at D/S Plantation Bridge site: a site considered to replicate roach captures at Lamas Hall (Figures 10 &11). Discovering the reasons for these absences at both sites would require detailed investigation, currently beyond the remit of this report.

Dace density and biomass estimates in 2019 derive from 2 fish over 99 mm FL. Both individuals are aged at 2+. A further 6 dace below 99 mm FL are recorded (Table 6), aged 1+. Historic data indicates demographic structure for dace at this site follows a pyramidal organisation with high numbers of juvenile fish at the base of the pyramid supporting decreasing numbers of older fish towards its apex. Typically, representatives from at least 4 consecutive year classes are present. This population structure holds true for 9 of the previous surveys for dace at this site.
The absence of older year classes in 2019 suggests a change in the population structure has occurred between 2016 and 2019 although, given the generally low population, this could be a chance effect.

The largest **pike** recorded in the 2019 survey, a fish of 2.5 kg (5½ lbs) falls short of the more usual sized pike at this site: individuals of 4 kg (8lbs) or more regularly feature in historic survey data. Table 6 indicates 15 fish over 99 mm FL represent the pike population at this site in 2019. Representatives from 3 or possibly 4 consecutive year classes are indicated, 70% of which are aged 2+. With few exceptions, historic captures at this site replicate the population structure, differing only by the number of individuals caught and ultimate year class indicated. Historic data suggest larger pike recorded at this site are 8 ~ 10 years old, are still active and grow well. Data also inform the future of pike at this site with distinct spawning success, survival and recruitment to the population evident.

Eel biomass estimate at this site in 2019 is significantly higher than estimates since 2007; the same is true for density estimates. This bucks the national trend. Detailed analysis indicates the average size of eel caught in surveys between 2006 ~ 2019 is higher than in surveys prior to 2007 and stays within 20% of their average value. This effectively means that since 2007, little if any recruitment to the eel population occurs at this site and by deduction that eel at this site are of a high average size. Relating density and biomass estimates at this site confirms the previous findings (Figures 12 & 13). Further support is available when considering the 2019 eel captures at this site. In 2019, the eight eel caught give a density estimate of 0.33 fish / 100 m^2 and biomass estimate of 89 grams / 100 m^2.

Intriguingly, a greater number of eels are recorded in surveys prior to 2007 but their average size is significantly less. In some cases, eel less than 150 mm FL are recorded; eel of this size qualify as elvers. The presence of elver at this site historically indicates that it was possible for them to navigate past Buxton and Horstead Mills. However there is no evidence of this since 2007 so eel passes at both sites would significantly aid their upstream progress.

D/S Buxton Mill

Survey site characteristics

As the name suggests, this survey site is situated a short distance downstream of Buxton Mill. Unlike the deep pool and riffle formed immediately below the Mill, the entire 170-metre survey length reflects the heavily modified classification assigned to the navigation; consequently, hydraulic regime and associated hydro-morphology are limited. Attributes such as flood plain connectivity, meanders and flow heterogeneity to name a few are restricted or non-existent at this site.
The 2019 survey site lies within a straightened section of the river; historic survey length varied from 150 to 200 metres. Channel width in 2019 is 11 metres; a reduction of 5 metres from that of

2002. This is due in part to accumulated marginal sediment bought about by reduced frequency of bankside maintenance since 2010. Another reason for sediment accumulation and changes to hydro-geomorphology at this site is the influence of regular well-meant water management measures applied upstream, whereby simulated mill use exaggerates the downstream hydraulic regime and sediment transport.

Deep accumulations of silt are evident throughout the survey length and prolific algal mats smother the riverbed in places. Eel like to inhabit the deep sediment and can prove difficult to catch during surveys. Stands of burr reed, reed grass and sedge along with common marginal plants (water mint, marsh marigold, purple loosestrife) consolidate the marginal sediment deposits, while fronds of submerged burr reed, starwort and curled pondweed rooted in the silt substrate sway in the generally sedate river flow.

The main volume of water flows close to the right hand bank along the majority of the survey length maintaining the steep drop between bank and bed. In some places a more gradual transition occurs, especially on the left bank, creating more varied marginal habitat. Accumulated sediment is especially noticeable in the lee of the solitary overhanging willow growing approximately 1/3rd of the way along the survey length. The accumulated silt, anchored by the tree's roots, narrows the river slightly and accelerates water flow past the willow.
The majority of the large adult chub recorded at this site reside under this tree. Chub are also evident below a small stand of overhanging willows just below the bottom limit of the survey site. Comprehensive data from 12 surveys are available for this site. From 2002 to 2010, data are collected annually, while the remaining 3 surveys (2012, 2016 & 2019) provide data every 3 years.

Species	Total Number recorded	Number of fish over 99 mm FL
Chub	30	26
Dace	18	11
Eel	19	19
Gudgeon	7	1
Lamprey	3	3
Perch	11	9
Pike	21	21
Roach	34	2
Stone loach	20	2
Tench	1	1

Table 7: Species list and captures recorded in 2019 survey at D/S Buxton Mill survey site. Total number and number of fish over 99 mm FL shown. Surveyed area 1870 m^2 (length 170m x width 11m)

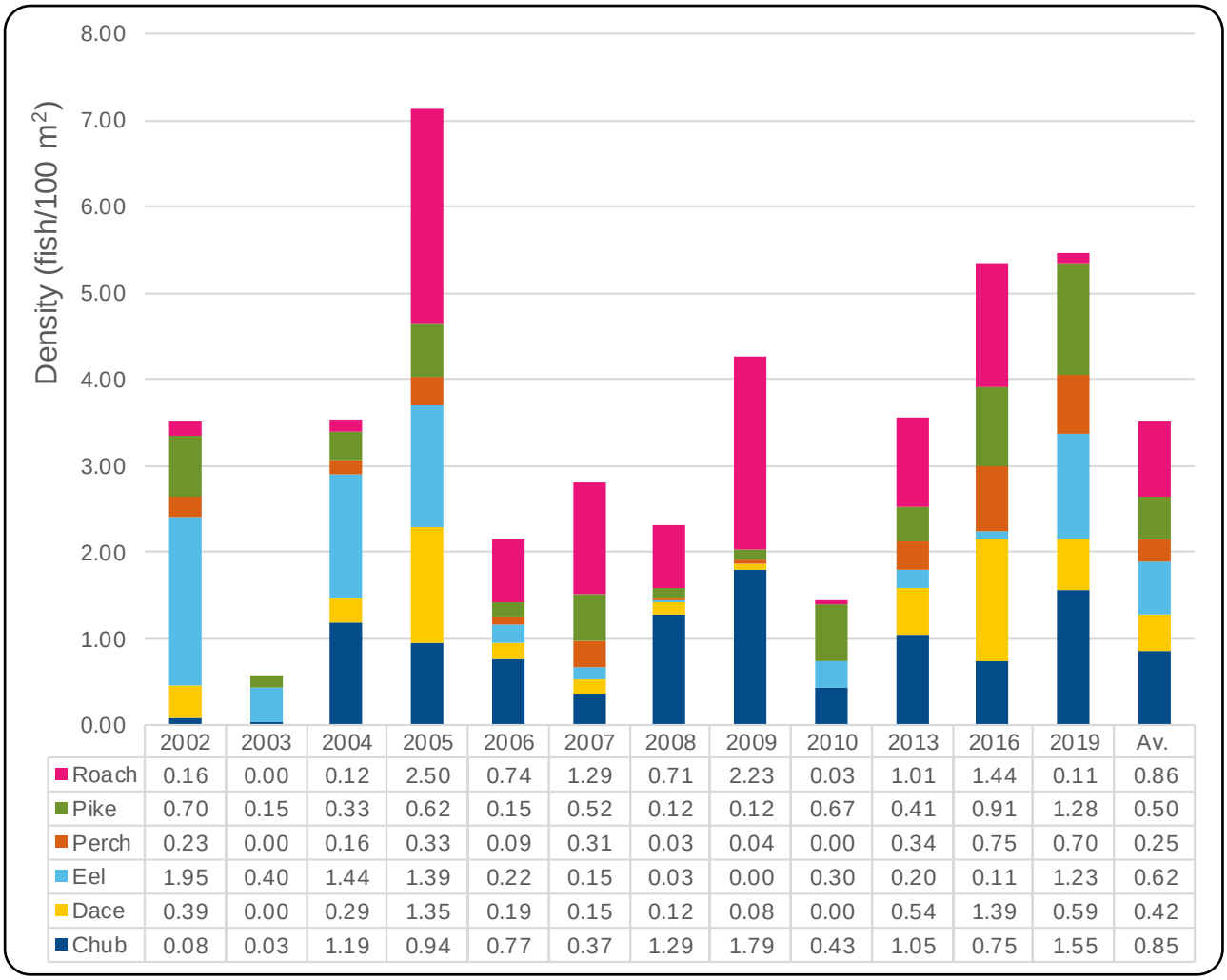
Table 7 indicates the species assembly and number of each species caught in the 2019 survey. Of the 134 fish captured, 95 are over 99 mm FL. Captures in 2019 include 10 species of fish: chub, dace, eel, gudgeon, lamprey, perch, pike, roach, stone loach and a single tench. Within the 2002 ~ 2019 surveys, there are records for 15 species. The 5 species absent from the 2019 captures are: bream, carp, rudd, ruffe & stickleback.

Eel, lamprey and stone loach represent 3 of the important indicator species used for WFD classification of chalk derived rivers. Bullhead and trout, the remaining 2 indicator species, are absent. Anglers catch trout in Buxton Mill pool and riffle immediately downstream but they are absent from any official survey to date. Bullhead are absent from the survey sites bar one, D/S Aylsham Road Bridge.

Long-term density at D/S Buxton Mill survey site

Observations: long-term density (figure 14)

The data used to produce Figure 14 derive from adult fish over 99 mm FL. This is relevant because Figure 14 indicates dace are absent in 2003 & 2010, however, young fish were present in these years. Dace density estimate in 2019 is above the site long-term average but is less than half that of the peak density estimate recorded in the previous survey in 2016 (Figure 14).
The pattern over time is variable with peaks in 2005 and 2016 but very low numbers in some of the intervening years. This could be due to natural population cycles or changes in the numbers of dace inhabiting this reach due to changes in conditions such as vegetation growth.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	Av.
Roach	0.16	0.00	0.12	2.50	0.74	1.29	0.71	2.23	0.03	1.01	1.44	0.11	0.86
Pike	0.70	0.15	0.33	0.62	0.15	0.52	0.12	0.12	0.67	0.41	0.91	1.28	0.50
Perch	0.23	0.00	0.16	0.33	0.09	0.31	0.03	0.04	0.00	0.34	0.75	0.70	0.25
Eel	1.95	0.40	1.44	1.39	0.22	0.15	0.03	0.00	0.30	0.20	0.11	1.23	0.62
Dace	0.39	0.00	0.29	1.35	0.19	0.15	0.12	0.08	0.00	0.54	1.39	0.59	0.42
Chub	0.08	0.03	1.19	0.94	0.77	0.37	1.29	1.79	0.43	1.05	0.75	1.55	0.85

Figure 14 Long-term density estimates for 6 key species over 99 mm FL at D/S Buxton Mill survey site. Note change to survey schedule after 2010.

Chub are resident at this site, the only site of the 5 where they are present in every survey. Not surprisingly, the largest chub across all 2019 surveys was caught at this site (Table 2). In 2019, chub density estimate is the second highest recorded, significantly higher than the site long-term average and within 15% of the highest density recorded in 2009. Chub density estimates display peaks and troughs over time, however neither peaks nor troughs show a cycle demonstrating regular spawning or recruitment. Juvenile captures in 2008 and the years prior do not explain the peak density recorded in 2009 suggesting the numbers of chub caught here relate more to pre or post spawning aggregations. The shallow water running over gravels below Buxton Mill is one of just 3 suitable chub spawning areas between Buxton and Horstead Mill; D/S Buxton Mill survey site is the nearest available area downstream of Buxton Mill to provide the cover and deep water that adult chub prefer, which may explain the high numbers found here.

The 2019 **roach** density estimate is the 3rd lowest estimate for the species across the 12 surveys, a significant decline compared to 2013 & 2016. However, like dace, the numbers of roach caught at this site is variable with no obvious regular population cycle. It is likely to be a combination of factors affecting the population and their distribution, including mill operating regimes at Buxton Mill and others.

Pike physiology (long & thin), rapid growth and survey timing almost guarantees their inclusion in every survey at this site; even a 1+ fish would be near or over 99 mm FL. In context, most round species of fish would not attain 99 mm FL until they are 2 or even 3 years of age. The 2019 estimate represents the highest peak across all surveys. The site long-term average density estimate is 0.5 fish / 100 m^2; the highest long-term average estimate for pike across all 5 sites. The 2019 pike density estimate at this site is almost 3 times that of the site long-term average and when compared to the 11 previous surveys can on occasion be a magnitude higher (Figure 16: 2003, 2006, 2008 & 2009). Although the largest pike recorded in 2019 came from D/S Plantation Bridge (962 mm FL: 8750 grams; 19lbs 4 ozs) this site is capable of producing pike of comparable and greater size. Anglers report pike in excess of 20 lbs (975mm FL, 9100 grams) from this site to corroborate this statement.

In 2019, **eel** density estimate at D/S Buxton Mill site is 1.23 fish / 100 m^2; this is the highest estimate recorded since 2005; twice that of the site long-term average and a considerable improvement across the intervening survey estimates. Observations at the time of survey indicate higher eel density than shown; the dense filamentous algae smothering the deep sediment that they inhabit prevented the capture of numerous individuals. Eel are absent from the survey data in 2009; none were captured and more unusually none were observed at the time of survey. Of the 19 eel captured and recorded in 2019, 42% are less than 320 mm FL.

Of the 5 sites considered in this report, D/S Buxton Mill is the only site displaying a consistent **perch** population. Barring 2003, perch are present in all surveys, although only juveniles were caught in 2010 (therefore absent from the data reported here). Since 2010, perch density estimates have increased significantly; the 2019 perch density estimate: 0.7 fish / 100 m^2, represents a 100% increase compared to the 2013 estimate and is close to the maximum estimate in 2016.

Long-term biomass at D/S Buxton Mill survey site

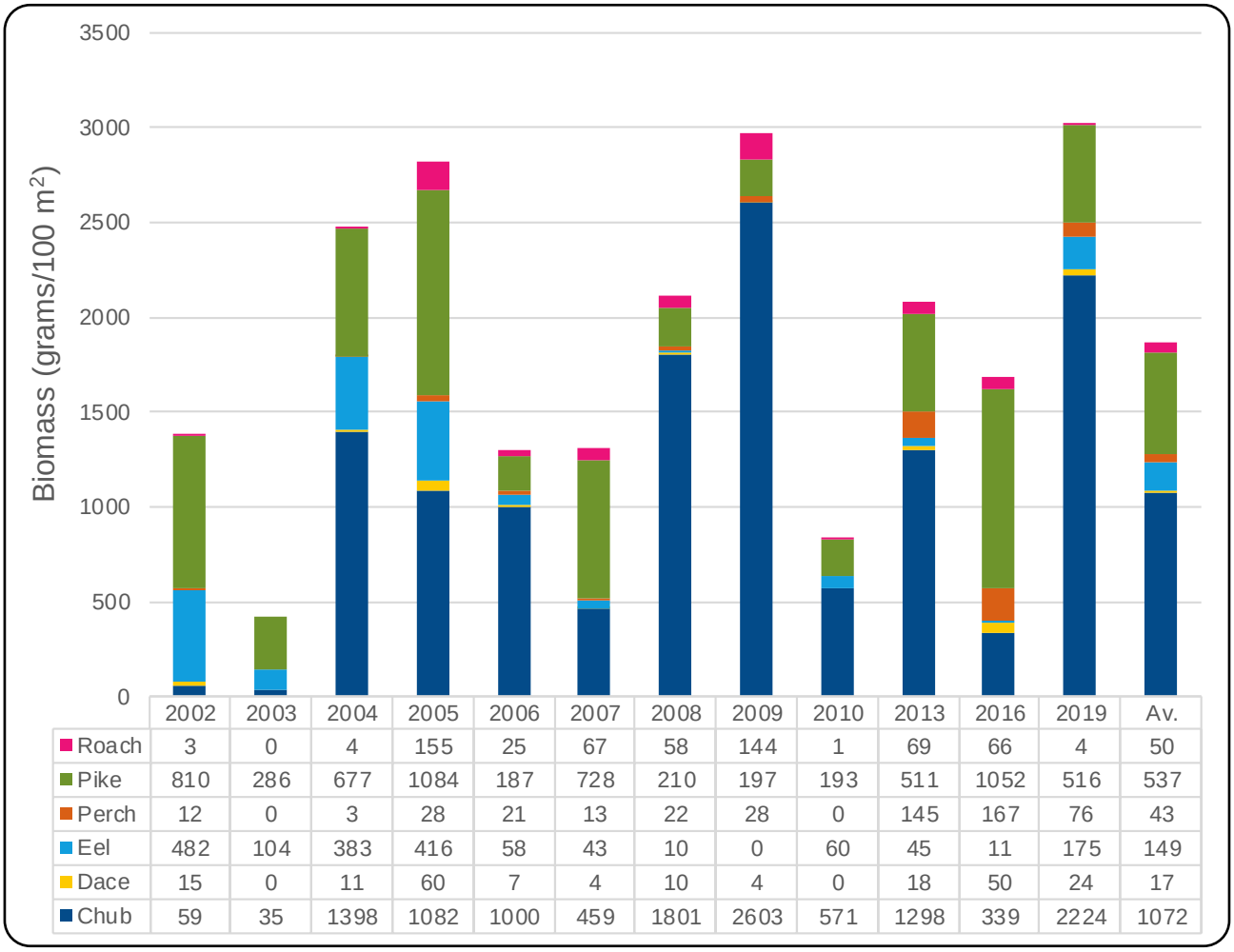
Observations: long-term biomass estimates **(figure 15)**

Dace biomass estimate in 2019 is above the long-term average estimate at this site but is a decrease compared to its value in 2016. Dace biomass estimate rarely achieves more than 3% of the combined biomass of the key species across all surveys at this site. In 2019, dace biomass estimate is less than 1% of the combined biomass of the key species considered. Dace biomass estimates peak in 2005 and 2016, matching the observed peaks in density estimates.

Chub biomass estimate in 2019 is 2224 grams / 100 m^2; close to the peak estimate recorded in 2009 and twice the site long-term average. Chub biomass estimates correlate very strongly to chub density estimates (R_{value} = 0.96) and as noted for density estimates display a jumbled, almost randomised estimates with no discernible pattern to indicate good spawning years or good recruitment. In most surveys, successive year classes of young fish are poorly represented or missing entirely. E.g. of the total 244 individual fish recorded across the 12 surveys only 14 individuals (5%) are less than 99 mm forklength. High biomass estimates are due to the high number of mature adult fish captured at the time of survey, e.g. 2004, 2008 & 2009 when the smallest fish of the 85 recorded in the 3 surveys, measured 390 mm FL (age 10 approximately).

Pike biomass estimate in 2019 falls just short of the site long-term average and is the 4th highest below the peak value recorded in 2005 (Figure 15, data table). Of the 21 pike captured in 2019, 12 measure less than 251 mm FL: within the 15 pike captured in 2016, 2 measure less than 251 mm FL. This indicates a higher

proportion of juvenile fish in 2019. Biomass estimates for the respective surveys reflect the change in population composition with the 2016 biomass estimate almost twice that of 2019 despite fewer fish recorded.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	Av.
Roach	3	0	4	155	25	67	58	144	1	69	66	4	50
Pike	810	286	677	1084	187	728	210	197	193	511	1052	516	537
Perch	12	0	3	28	21	13	22	28	0	145	167	76	43
Eel	482	104	383	416	58	43	10	0	60	45	11	175	149
Dace	15	0	11	60	7	4	10	4	0	18	50	24	17
Chub	59	35	1398	1082	1000	459	1801	2603	571	1298	339	2224	1072

Figure 15 Long-term biomass estimates for 5 key species over 99 mm FL at D/S Buxton Mill survey site. Note change to survey schedule after 2010.

Eel biomass estimate in 2019 mirrors the upswing in density estimate for the year (Figure 14). Eel biomass estimate in 2019 is above the site long-term average for the species and considerably above biomass estimates for the 7 surveys preceding 2019. However, it has not regained the higher levels seen in the earlier years.

Roach biomass estimate in 2019 is a shadow of previous estimates, dropping from its highest peak estimate in 2005 to its latest estimate of 3.8 grams / 100 m^2. Roach density estimate (Figure 14) declines similarly for adult roach but the capture of over 30 juvenile roach in 2019 offers hope for the future (Table 7). Roach biomass estimates at this site contrast with the high roach density estimates. In most surveys, juvenile roach outnumber their adult cousins, accounting for 50% or more of the total number caught while adult roach are at times scarce if present at all. This is not always the case however. In the years with greatest roach numbers (2005 and 2009), a higher proportion of adults were present. It is possible these adults shoal together and are present in this reach in some years and not in others. This could be pre or post-spawning behaviour hypothesised for chub at this site, so too the high roach density observed in 2005 at D/S Aylsham bypass site (figures 6 &7).

Although adult **perch** are present in most surveys, biomass estimates rarely exceed 25 grams / 100 m^2: roach biomass estimates are frequently higher than this. Figures 14 & 15 indicate that prior to 2010 perch was struggling to maintain their presence at this site. This aspect changes in the later surveys; the 3 results from 2013 onwards are the highest on record, despite a complete lack of >99mm FL fish caught in 2010. The mix of sizes, including juveniles, caught in 2019 bodes well for continued survival of perch in this reach.

Comments / Interpretation

The site at D/S Buxton Mill has by far the highest population of **chub** out of all the sites surveyed and 2019 was no exception. It offers good spawning gravels at the mill along with 2 other sites downstream and suitable conditions to thrive throughout the survey reach. This high predator biomass (together with pike) seems to have a negative impact on some prey species. In particular, roach and dace; both species are represented by relatively small numbers of small fish in 2019. Occasional captures of aggregations of adult roach seem to be the exception but were not caught this time. Perch seem to be less affected and in fact, on average, this is their best site of the five, particularly in the years from 2013 onwards. The good amounts of plant growth in this slow, ponded section probably provide the cover they like to hide and camouflage themselves in.

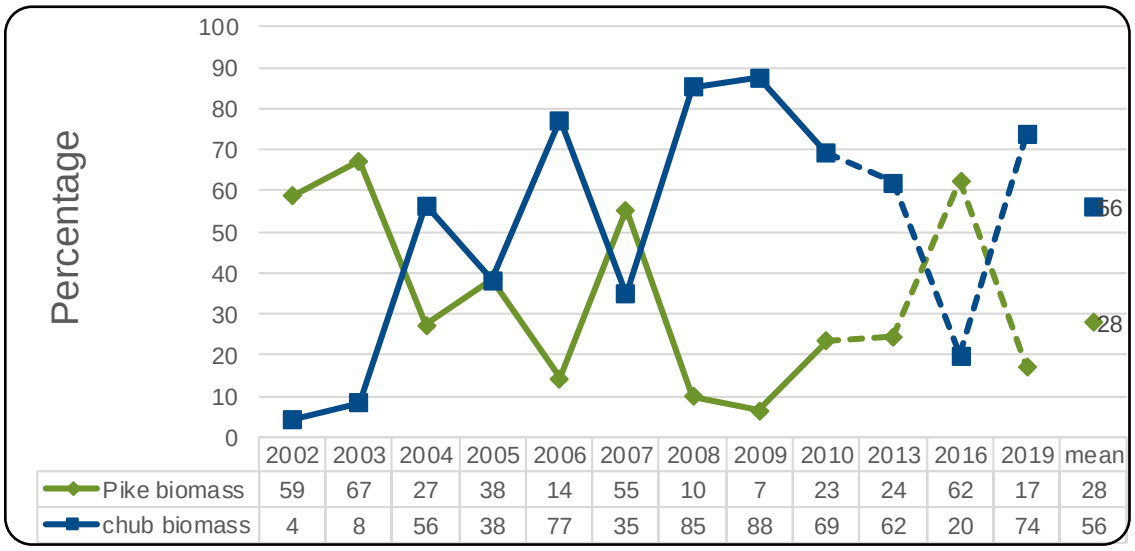
Table 4 indicates the number and size of **eel** caught from this site in previous surveys. Between 2002 and 2005, this site supports healthy numbers, albeit significantly smaller than in the 1970s and 80s. This is followed by a lengthy period of very low numbers up to 2016. None of the eel caught in this period are below 325 mm FL meaning limited, if any, upstream migration of elvers is occurring.

Table 4 showing numbers of eel caught, maximum, average and minimum length (mm FL) across surveys from 2002 ~ 2019. Metrics are not available for 2003 & 2004 because eel are counted, not measured at that time. No eel caught in 2009 survey.

Survey year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019
Eel density estimate (fish / 100 m^2)	23	13	33	34	7	5	1	0	8	6	2	19
Max length (mm)	750	n/a	n/a	645	600	580	550	n/a	530	540	425	580
Average length (mm)	570	n/a	n/a	520	492	522	550	n/a	461	470	375	388
Min length (mm)	450	n/a	n/a	425	340	450	550	n/a	325	365	325	215

In 2019, eel numbers increase significantly. In addition, there are noticeable decreases in minimum and average eel length (Table 4). Taken together these aspects are indicators of recruitment (by migration) to the population. Maximum size remains high, indicative of mature eel moving downstream through the site on their spawning migration as previous surveys show. The 2017 upgrade to the eel pass at Horstead Mill, downstream and increasing numbers of returning elver, probably account for the upsurge in smaller eel at this site. The eel pass will assist mature eel on their seaward journey, too.

Pike and chub rival each other for the prime share of biomass and account for more than 60% of the combined total across all surveys (See Figure 18). Correlation between chub and pike biomass indicates a very strong inverse relationship (R_{value} = -0.97) indicating that when chub biomass estimate is high pike biomass estimate is low and vice versa.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2013	2016	2019	mean
Pike biomass	59	67	27	38	14	55	10	7	23	24	62	17	28
chub biomass	4	8	56	38	77	35	85	88	69	62	20	74	56

Figure 16: Pike & chub biomass estimates as percentage of total combined biomass for the key species under consideration at D/S Buxton Mill Survey site 2002 ~ 2019. Note dotted line to denote changes in survey schedule.

Health of the fish populations

Eel are present in nearly all surveys across the 5 sites but significant declines are apparent over time; in some cases by more than 98% comparing max to min numbers. However, in the most recent survey, the population has increased slightly: from <0.1/100m^2 minimum density to 0.38 and from low biomass estimates of <30g/m^2 to 184 (averages for the whole river). One reason for this may be the elver pass installed at Horstead Mill in 2017. Larger eels may also be benefitting from the considerable population of signal crayfish as prey items.

In angling, **pike** are synonymous with the Broads, specimen sized pike especially so. As the major river flowing through Broadland and connecting the associated Broads, it is no surprise that pike are prolific in the non-tidal reaches of the river Bure too. They have a healthy presence at all sites and a relatively stable population through all the years – 2019 is no exception. As noted above, their ability to make use of a wide range of prey items, including cannibalism, helps them survive and thrive. There is evidently enough vegetation to act as cover for their ambush style of hunting, although plants are scarce at D/S Aylsham Bypass and pike population relatively low.

Chub in the middle Bure are almost entirely limited to the most downstream site, D/S Buxton Mill. Angling results for chub in this part of the river indicate they attain specimen size; 6lb fish are reported along with numerous 4 and 5 lb fish. These are natural spawned fish that have recruited to the population over many years. Some of the more mature specimens are 16+ years old. Stocked in moderate numbers from the same strain and at approximately the same time (1970's), as chub in the River Wensum, chub in the River Bure have not expanded upstream in the same way. This could be due to a lack of lateral connectivity between floodplain and river, substantial barriers to migration and/or insufficient habitat.

That said chub are recorded from one site upstream of Buxton Mill: limited numbers were caught from Lamas Hall in 2004 & 2005. Their brief presence and arrival at Lamas Hall relates to the complex of millstreams, carriers, bypass channels and leats that exist across the catchment. At times of extreme flood, one such leat /carrier connects hydraulically to the main river upstream of Buxton Mill via the flood plain. The same leat skirts around Buxton Mill before joining the main river downstream of the mill. Under these conditions, the leat becomes a fish pass for those fish powerful enough to swim against the flow. These chub are thought to have used this route to migrate around and above Buxton Mill. It is disappointing and surprising that chub did not establish above Buxton Mill given this passage exists and water quality is good.
Despite similar networks of channels and leats present between mills further upstream, even in times of flood, there is no lateral or hydraulic connection between them and the river. Opportunities for chub to migrate further upstream are therefore restricted.

As with pike, chub can utilise a range of prey species, however, they are known to particularly favour crayfish and to do well when signal crayfish are present in good numbers. This is probably one reason behind their success here and the increase in population over time, as the signal crayfish numbers have been reported to have increased in recent years.

Dace numbers are variable from site to site and time to time. Small individuals dominate the population; they do not seem to thrive well into adulthood. Saying that, discrete populations of large dace exist in the river. Dace prefer fast flow speeds (rheophilic) and cover provided by vegetation. For most of its length, the Bure therefore does not provide ideal conditions. The channel has been widened and deepened, which produces slow flow speeds. The amount of submerged vegetation and overhanging trees is also very limited.

Roach tend to do best in the middle portion of this reach, especially D/S Plantation Bridge. The habitat at the uppermost site at Aylsham is less suitable for roach, having a more diverse morphology and less ponded areas. At the lowest site at Buxton, the high chub population may limit roach and sudden releases of water from the mill may also be having a detrimental effect. But 2019 was a good year with overall population well above the long term average. Individual sites do vary from year to year, e.g. 2019 was a poor year for two sites - Oxnead Bridge and D/S Buxton Mill. However, 2010 was an exceptionally poor year across all sites. It is not know why this was, but happily the overall population has since recovered and gone from strength to strength. The population is still not high compared to some other rivers and to

the lower Broadland rivers. It is comparable to the population level in the Wensum. It is not possible to go into a detailed explanation of the reasons here.

Perch are a relatively minor component of the fish population at all sites and dates. Their population is relatively steady but has been slightly elevated in the last 3 surveys, especially biomass and most noticeably at D/S Buxton Mill. This indicates fish are reaching a larger size at this site now; the reason is not immediately clear but perch predate on small crayfish and may be benefitting from increased populations.

Trout favour the upper river, as would be expected from their preference for higher flows and more natural, flowing channels compared to impounded sections. The individuals caught at Aylsham seem to be a mix of stocked and naturally recruited individuals while those at D/S Plantation Bridge all seemed to be stocked fish. In common with perch, the last 3 surveys have seen higher populations, but this has been driven by results from Aylsham rather than Buxton.

Water Framework Directive (WFD)

A number of elements determine WFD classification for the central section of the River Bure, identified by waterbody number GB105034050932.

Overall classification is Moderate (2019 rating)

Some of the elements used for classification are below:

Biological element:

- fish classification is Good (2016 classification: Moderate)

The 2019 fish classification uses survey data from 7 sites surveyed within the 6 year period prior to the classification cycle and linked to the waterbody. In this instance all data derives from surveys completed in 2016. These are the classifications at individual sites:

D/s Aylsham Bypass	Burgh Hall Farm	U/S Oxnead Bridge	D/S Plantation Bridge	Lamas Hall	D/S Buxton Mill	D/S Mayton Bridge
Moderate	Moderate	Good	Moderate	Moderate	Good	High

- Invertebrate classification is Good (changed from High in 2016).
- Macrophytes and phytobenthos combined classification are not assessed in either cycle.

Physico-Chemical element:

- Classification in 2016 and 2019 is Good

Specific pollutant element:

- Classification in 2016 and 2019 is High.

Hydro-morphological supporting elements - Hydrological regime:

- Supports Good for both 2016 and 2019 classifications

Discussion

The fish community found during this survey is much as expected for a river of its size and location in the country. A diverse fish community is present and there is abundant evidence of reproduction. Although some individual sites are classified as moderate under WFD, overall the river is classed as good for fish. The river overall is also healthy, as shown the WFD classifications across all monitored elements being good or high.

Some fish have restricted distributions. For example trout are only present in the upper section but this is not unexpected given their preference for upper reaches with fast flows. The restriction of chub to the lowest site is likely to be less natural and more related to barriers to movement formed by mills and weirs. D/S Plantation Bridge is the stand out site for the quantity and diversity of fish present.

Bream are not recorded in the surveys but information from anglers indicates two large shoals are present - one between Horstead and Buxton and the other between Buxton and Oxnead. Bream obtained from a Norwich amenity lake were relocated to bolster the upstream stock. Their nomadic nature and shoaling habit means they rarely feature in survey results. Their presence in the capture records would improve the WFD status.

There is room for further improvements to the fish community i.e increases in numbers and sizes of fish of angling interest. Morphology problems identified are:

- Poor habitat diversity due to uniform, over-engineered channel morphology
- Lack of bankside trees for shade and cover
- Barriers to fish movement

Some projects have already been undertaken by the EA, angling clubs and others and more are planned but there is scope for further beneficial works. This includes habitat modifications, flow refuges, tree planting and fish passes or structure removal.

Another impact on the fish populations is caused by the presence of significant populations of signal crayfish, an alien invasive species. As well as nearly wiping out the population of native white-clawed crayfish, this species preys on fish eggs, competes for food and causes increased bank erosion and thus siltation. There is however a benefit for the chub population. The biomass, size and growth rate of chub increases once the fish are big enough to eat crayfish.

A problem that has occurred on at least one occasion is caused by insensitive operation of mill gates. When the gates are opened so as to cause a large, rapid drawdown of water in the upstream reach, many fish are washed through. When the mill gates are closed again, the fish can't pass back over the structures.

No major pollution incidents have been recorded in recent years.

In common with many rivers in our dry and agricultural region, lack of water can be a problem. This impacts aspects of river habitats such as the ability of the river to clear silt, suitability of flow speeds for rheophillic species such as dace and trout and dilution of sewage effluent and other polluting substances. The Environment Agency works to manage abstraction pressures through its Abstraction Licencing Strategy, regulation of abstractors and working with water companies.

If you would like to discuss the information presented in this report, please contact:

- Jeff Compton. Monitoring officer, Assessment and Reporting
- 03708 506 506
- enquiries@environment-agency.gov.uk

If you would like to discuss future management of this fishery, please contact:

- Kevin Grout, Fisheries specialist, Fisheries, Biodiversity and Geomorphology
- 03708 506 506
- enquiries@environment-agency.gov.uk

Before you go fishing don't forget:

- You must have a valid Environment Agency rod licence and permission from the fishery owner;
- You must comply with the fisheries byelaws;

- The coarse fish close season (15th March to 15th June inclusive) applies to all rivers, streams and drains in England and Wales but not most stillwaters. Stillwater fishery owners can still have their own close season and rules, so please check with them before setting out.

Report illegal fishing:

If you see any fishing, netting or trapping you think may be illegal, please do not tackle it yourself. Call us immediately on 0800 80 70 60 and tell us:

- Exactly where the alleged offence is taking place;
- What is happening;
- How many people are involved and their descriptions;
- The registration numbers of any vehicles involved.

If you prefer to remain report an environmental crime anonymously call Crimestoppers on 0800 555 111 or https://crimestoppers-uk.org/give-information/give-information-online/.