Fish population survey report

River Wensum (central) 2019 (temporal)

This report provides a summary of results from recent fish population surveys on the River Wensum between Fakenham and Hellesdon. Data from six surveys conducted in 2019 assess the health of the river and enable successful management of our principal fisheries.

1lb 7 oz. Roach caught in the central section of the River Wensum, 2019.

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 the fish stocks in its care, 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 Wensum. Data from 6 sites, surveyed annually, 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.

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Summary

- Six temporal sites, surveyed annually, on the River Wensum were surveyed by PDC electric fishing between July and October 2019;
- 15 species of fish were present (bream, bullhead, chub, dace, eel, gudgeon, lamprey, perch, pike, roach, rudd, stickleback, stone loach, tench and trout)
- In total 2079 fish were captured; of which 541 were above 99 mm Fork Length (FL) (see Factors affecting survey results).
- Eel, gudgeon and pike were the most widespread species, being recorded at all sites;
- Based on fish over 99 mm Fork Length (FL), an average density estimate of 4.9 fish per 100m^2 and biomass estimate of 1082 grams per 100m^2 were recorded across all sites;
- Roach were the most numerous species, whilst chub had the highest overall biomass.
- WFD indicator species are present throughout the river (bullhead, eel, lamprey, stone loach, stickleback & trout)
- For a second consecutive year, sea trout feature in the 2019 capture record.

Site locations

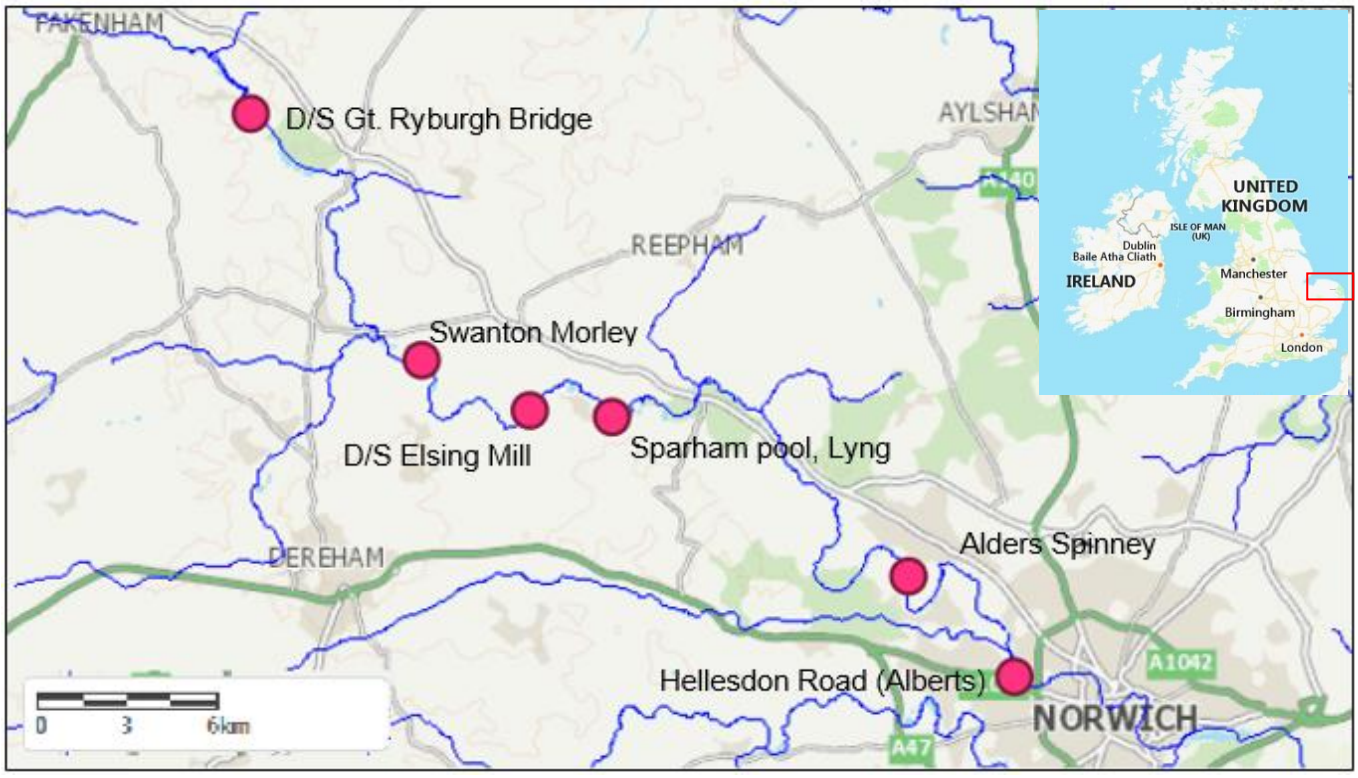


Figure 1
Map indicating location of the six annually surveyed sites in Norfolk and the UK. Sparham Pool, Lyng; is a recent addition to the 5 nationally driven temporal sites, initiated in 2016; funded by water resource revenue.

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

Site name	Survey date	Survey area (m^2)	Location (NGR)
D/s Gt. Ryburgh Bridge	31/07/2019	1312.5	TF9659326837
Swanton Morley	12/07/2019	2200	TG0180719361
D/S Elsing Mill	15/08/2019	2000	TG0510217838
Sparham Pool, Lyng	31/10/2019	1650	TG0763117653
Alders spinney	06/08/2019	1530	TG1667612847
Hellesdon Road (Alberts)	03/07/2019	2295	TG1991409798

Factors affecting survey results

Survey sites: The high number of existing barriers across the river Wensum tend to create separate fish populations. Few species are able to migrate freely if at all between the isolated sections of the river, exceptions are sea trout and barbel (EA, unpublished).
The same barriers to fish migration provide a mix of habitats, with over-deep, sediment rich ponded areas and slow flows above barriers to fast flowing, scoured mill pools below. Survey site selection requires careful consideration to ensure the site is representative of both; hydro-morphological and habitat features present.

All sites were 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 6 key species of fish 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; they too are included in this report when captured.
Water clarity at the time of survey was good at all sites. Lower than normal water level was evident at some sites due to prolonged dry weather preceding surveys. Macrophyte growth varied from site to site, with very little in stream growth evident at Swanton Morley or D/S Elsing Mill. In contrast, dense macrophyte growth was evident at D/S Gt. Ryburgh Bridge, Sparham Pool, Lyng, Alders Spinney and Hellesdon Road, (Alberts).

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.

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.**

Site name / Species	D/S Gt Ryburgh Bridge	Swanton Morley	D/S Elsing Mill	Sparham Pool, Lyng	Alders spinney	Hellesdon Road (Alberts)
Chub (max length)	0	502	302	538	**546**	480
No. caught	0	9	**23**	19	19	15
Dace (max length)	0	195	186	101	**262**	199
No. caught	0	4	20	1	**49**	15
Perch (max length)	0	**362**	0	170	254	230
No. caught	0	**9**	0	3	3	3
Pike (max length)	658	**806**	607	576	776	612
No. caught	8	9	**36**	7	10	5
Roach (max length)	142	281	211	0	242	**310**
No. caught	11	22	27	0	35	**64**
Trout (max length)	261	358	0	458*	0	**522****
No. caught	4	1	0	1	0	1
Other species	3sst, Bh, Gud, Ru, L, Mi, St lo	Bh, Gud, L, Mi, St lo	Gud, Mi	Bh, Gud, L, Mi, Te	3sst, Bh, Cb, Gud, L, Mi, St lo	Bh, Gud, Mi, St lo

Key: 3sst = 3 spined stickleback, Bh = Bull head, Cb = Common Bream, Gud = Gudgeon, Ru = Rudd, L = lamprey (sp), Mi = Minnow, St lo = Stone loach, Te = Tench
*Stocked fish identified by harpoon style tag, ** Confirmed Sea trout (2 years freshwater +2 years sea)

2019 Survey results

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

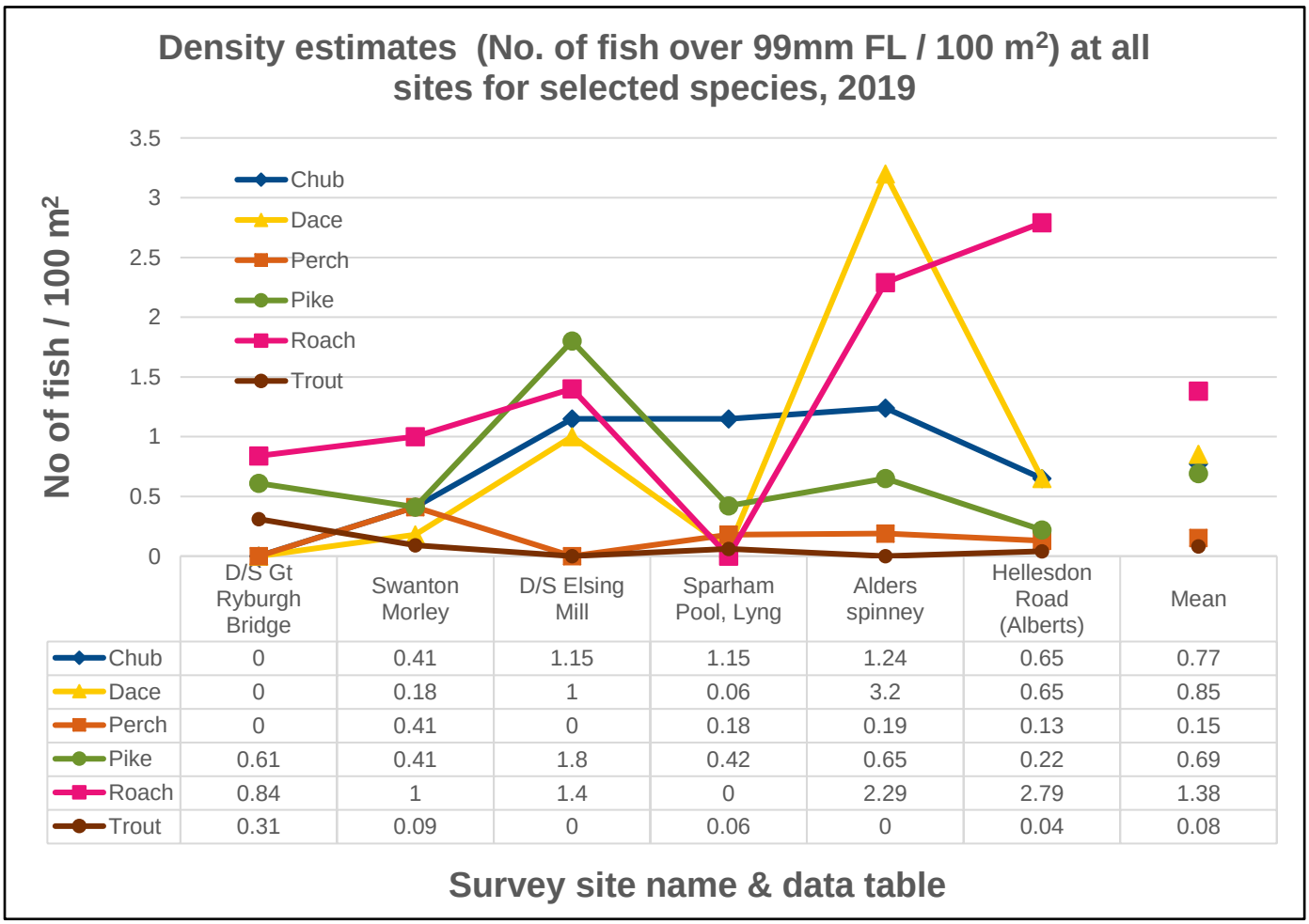
- Chub, 546mm FL recorded at Alders Spinney. Weight: 5lbs 12 ozs (2.63 Kg)
- Dace, 262 mm FL recorded at Alders Spinney. Weight 8ozs (0.23 Kg)
- Eel, 590 mm FL recorded at Alders Spinney.
- Perch, 362 mm FL recorded at Swanton Morley. Weight 2lbs 4ozs (1.1 Kg)
- Pike, 806 mm FL recorded at Swanton Morley. Weight 10lbs 14ozs (4.96 Kg)
- Roach, 310 mm FL recorded at Hellesdon Road (Alberts). Weight 1lb 7ozs (0.65 Kg)
- Trout, 522 mm FL recorded at Hellesdon Road (Alberts). Weight 4lbs 2ozs (1.9Kg)
- No chub, dace or perch over 99 mm FL are recorded from D/S Gt, Ryburgh Bridge

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

- 64 roach recorded from Hellesdon Road, Alberts; 149 fish in total from 5 sites
- 49 dace from Alders Spinney; 89 caught across 5 of the 6 sites
- 36 pike recorded from D/S Elsing Mill; combined total of 75 individuals across all sites
- 23 chub caught at D/S Elsing Mill; 85 chub recorded from 5 sites
- 4 Trout caught from D/S Great Ryburgh Bridge; 7 fish in total caught across 4 sites

Gudgeon and minnow are present at every site.

2019 Density estimates



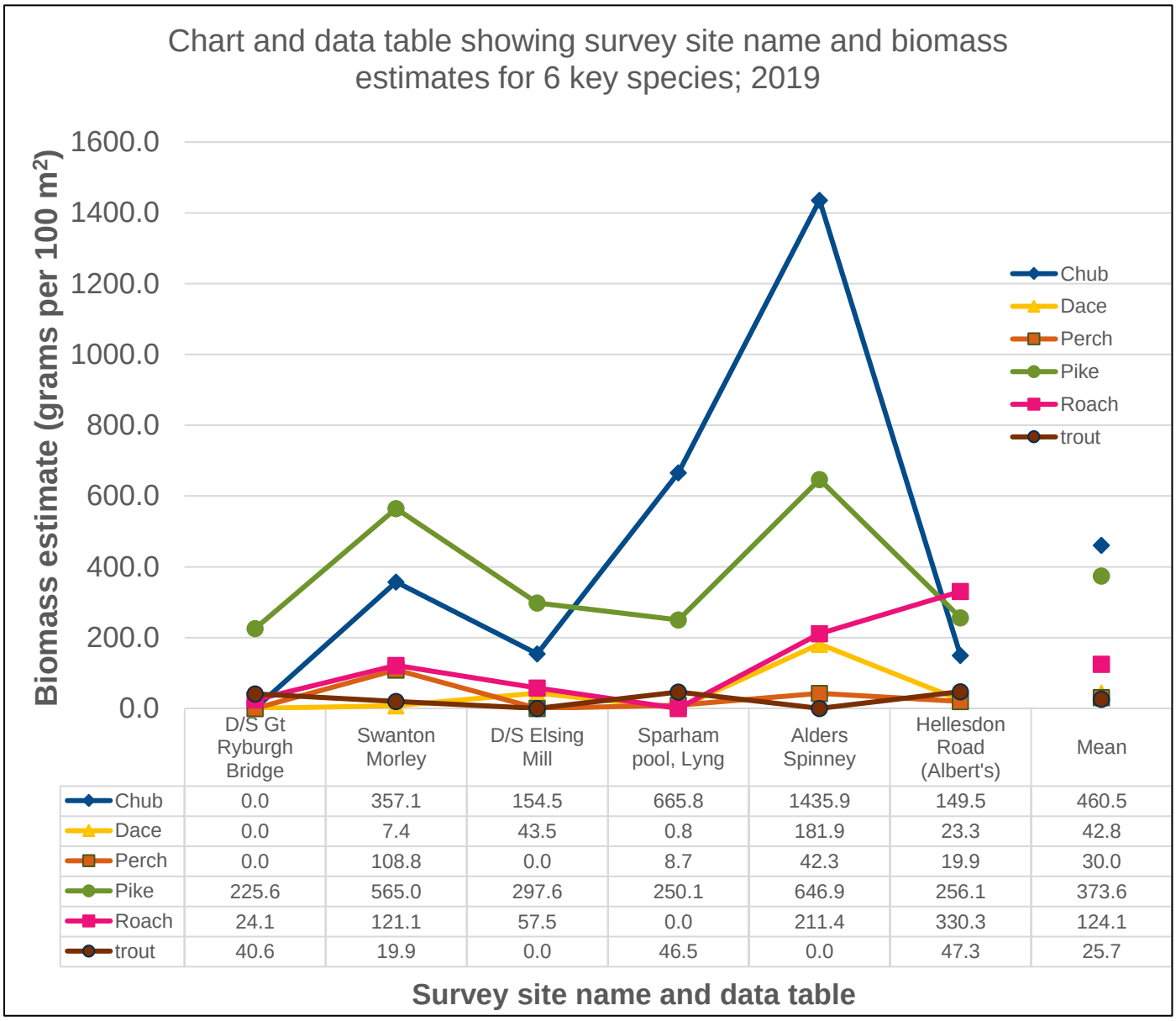
	D/S Gt Ryburgh Bridge	Swanton Morley	D/S Elsing Mill	Sparham Pool, Lyng	Alders spinney	Hellesdon Road (Alberts)	Mean
Chub	0	0.41	1.15	1.15	1.24	0.65	0.77
Dace	0	0.18	1	0.06	3.2	0.65	0.85
Perch	0	0.41	0	0.18	0.19	0.13	0.15
Pike	0.61	0.41	1.8	0.42	0.65	0.22	0.69
Roach	0.84	1	1.4	0	2.29	2.79	1.38
Trout	0.31	0.09	0	0.06	0	0.04	0.08

Figure 2 Density estimates of key species from each site. Estimates derived using fish over 99 mm FL. Mean estimates across all sites shown for comparison (mean estimate of chub & pike lie on top of each other on chart).

Observations: **(figure 2)**

- With the exception of the Sparham Pool site, roach density increases with distance from source (see also figure 3, long-term biomass estimates).
- Highest roach density (2.79 fish per 100 m^2) is from Hellesdon road, Alberts.
- Trout density peaks at the furthest upstream site (0.31 fish per 100 m^2) and decreases with distance from source
- The largest trout recorded was identified as a sea trout weighing 4lbs 2 ozs (1.87 Kg)
- Dace density estimates indicate a high degree of variability between sites
- Perch density at Swanton Morley (0.41 fish per 100 m^2) is almost 3 times the mean estimate (0.15 fish per 100 m^2)
- Pike density at D/S Elsing Mill site is the highest estimate across all sites (1.8 fish per 100 m^2); 8 times higher than the lowest pike density recorded at Hellesdon Road, Alberts (0.22 fish per 100 m^2).

2019 Biomass estimates



	D/S Gt Ryburgh Bridge	Swanton Morley	D/S Elsing Mill	Sparham pool, Lyng	Alders Spinney	Hellesdon Road (Albert's)	Mean
Chub	0.0	357.1	154.5	665.8	1435.9	149.5	460.5
Dace	0.0	7.4	43.5	0.8	181.9	23.3	42.8
Perch	0.0	108.8	0.0	8.7	42.3	19.9	30.0
Pike	225.6	565.0	297.6	250.1	646.9	256.1	373.6
Roach	24.1	121.1	57.5	0.0	211.4	330.3	124.1
trout	40.6	19.9	0.0	46.5	0.0	47.3	25.7

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

Observations: **(figure 3)**

- Total chub biomass in 2019 across all sites (2763 grams per 100 m^2) exceeds all other species
- Chub biomass estimate at Alders Spinney (1436 grams per 100 m^2) is the highest individual value recorded across all sites and accounts for more than 50% of the total chub biomass
- Pike biomass estimate exceeds all other species at 3 sites: D/S Gt Ryburgh, Swanton Morley & D/S Elsing Mill
- Highest pike biomass is recorded from Alders Spinney (647 grams per 100 m^2)
- Alders Spinney site has the highest combined biomass estimate (2518 grams per 100 m^2) for the key species considered.
- Dace biomass estimate is highest at Alders Spinney (182 grams per 100 m^2)

Long-Term density and biomass estimates

Notes: The following sections use long-term data collected between 2003 ~ 2019 inclusive. Trends and patterns at both site and section level are assessed and discussed for key species.

The River Wensum is classed as a Reference Course Principle Fishery. Five 5 sites are surveyed each year to provide a temporal overview of the fish population in the river (yearly monitoring). Data from all sites surveyed in a given year produce the long-term density and biomass estimate charts. One of the 5 temporal sites (Swanton Morley) changed from a spatial site (monitored every 3 years) to a temporal site in 2010. Consequently, data from 4 sites rather than 5 are used in 2004, 2005, 2007 and 2008 to generate density and biomass estimates. Although surveyed annually since 2016, data collected from Sparham pool, Lyng is not included in the long-term analysis due to the brevity of the data compared to the 5 other sites.

Survey area and rationalisation:

Survey length at each site is whenever possible, maintained in alignment with codes of practice and is a minimum of 150 metres. 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)**

Roach

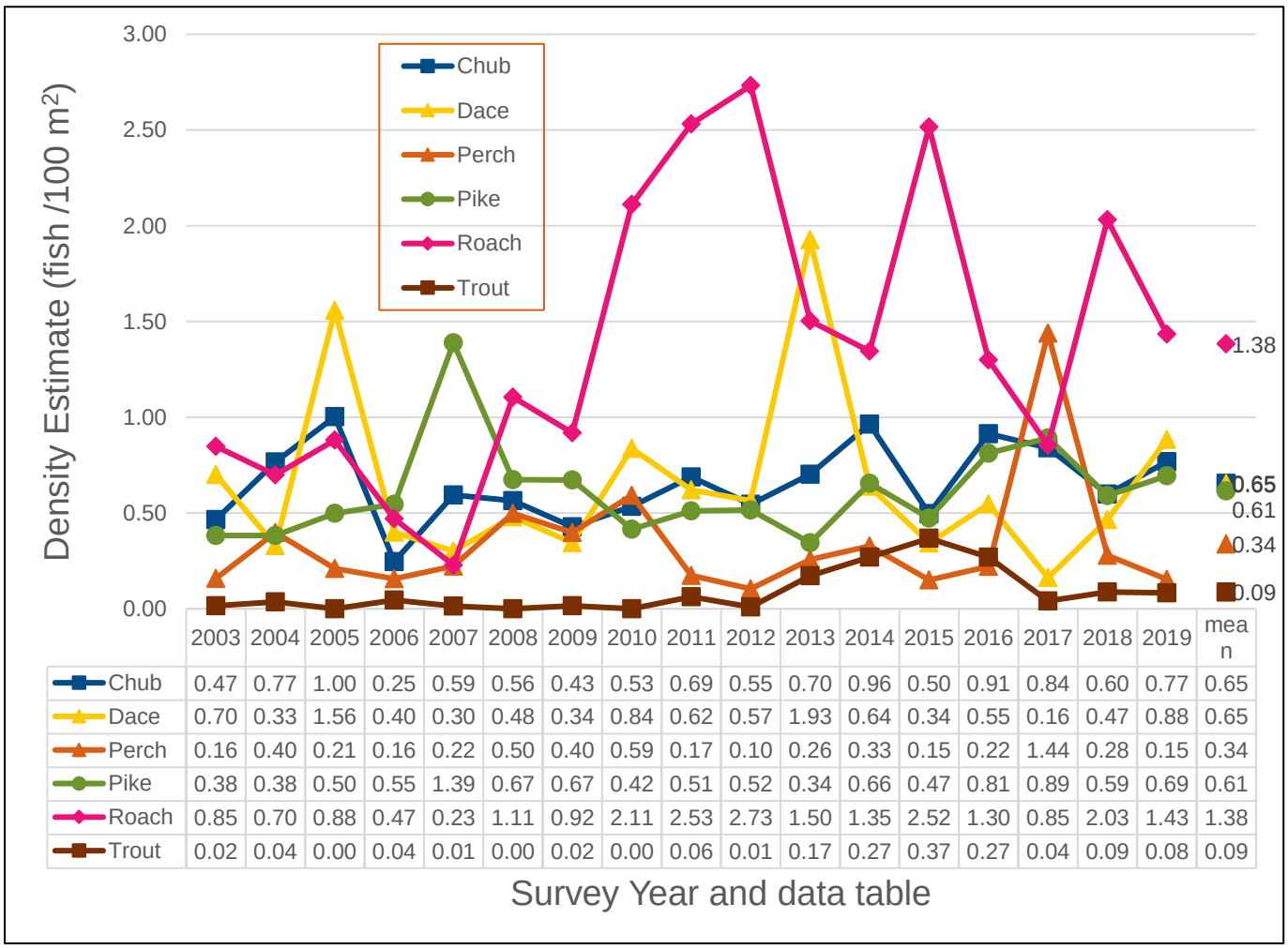
- The mean 2019 roach density estimate for the central section of the River Wensum (1.43 fish / 100 m^2) is higher than the long-term mean for the species (1.38 fish / 100 m^2).
- The 2019 roach density estimate is approximately half that of its peak estimate recorded in 2012 (2.73 fish / 100 m^2) but is over 6 times the lowest estimate recorded in 2007 (0.23 fish / 100 m^2).
- Although not as high as the peak density observed in 2012 two further peaks are evident in 2015 (2.5 fish / 100 m^2) and 2018 (2.03 fish / 100 m^2) suggesting a 3 yearly recruitment cycle. If this were the case, the 2019 survey estimate would lie on the falling limb of the 2018 ~ 2021 cycle.
- Prior to 2009, roach density did not exceed 1.11 fish / 100 m^2.
- Roach density increased threefold between 2009 to its peak estimate recorded in 2012.

Dace

- Dace density indicates a rapid, upward trend since 2017; the 2019 density estimate is 0.88 fish / 100 m^2.
- The 2019 dace density estimate is almost 30% higher than the long-term mean (0.65 fish / 100 m^2)
- Dace density shows a similar fluctuation to that of roach and at similar times. However, unlike roach, dace density decreased to its lowest estimate in 2017 (0.16 fish / 100 m^2).
- For the 14 years prior to 2017 and for the 2 years after, dace density exceeds 0.30 fish / 100 m^2.
- Dace density reached its highest value in 2013 recording a value of 1.93 fish / 100 m^2 a further peak of 1.56 fish / 100 m^2 observed in 2005. This could indicate an 8-year recruitment cycle, which would peak again in 2021. The 2019 estimate would lie on the rising limb of such a cycle.

Pike & Chub

- The 2019 density estimates recorded for pike and chub: 0.69 & 0.77 fish / 100 m^2 are higher than their long-term means (0.61 & 0.65 fish / 100 m^2 respectively).
- Since 2014 to date, density estimates for pike and chub are almost identical. In addition, the estimates exhibit a similar pattern over the period with peaks and troughs occurring at the same time.
- With the exception of an anomalous spike in pike density occurring in 2007 (1.39 fish / 100 m^2) the 2019 density estimate like the 14 other estimates stay within ± 40% of the mean over the 16 year period.
- The 2019 estimates for pike and chub represent part of a gradual overall upward trend noticed for both species over the last 5 years.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	mean
Chub	0.47	0.77	1.00	0.25	0.59	0.56	0.43	0.53	0.69	0.55	0.70	0.96	0.50	0.91	0.84	0.60	0.77	0.65
Dace	0.70	0.33	1.56	0.40	0.30	0.48	0.34	0.84	0.62	0.57	1.93	0.64	0.34	0.55	0.16	0.47	0.88	0.65
Perch	0.16	0.40	0.21	0.16	0.22	0.50	0.40	0.59	0.17	0.10	0.26	0.33	0.15	0.22	1.44	0.28	0.15	0.34
Pike	0.38	0.38	0.50	0.55	1.39	0.67	0.67	0.42	0.51	0.52	0.34	0.66	0.47	0.81	0.89	0.59	0.69	0.61
Roach	0.85	0.70	0.88	0.47	0.23	1.11	0.92	2.11	2.53	2.73	1.50	1.35	2.52	1.30	0.85	2.03	1.43	1.38
Trout	0.02	0.04	0.00	0.04	0.01	0.00	0.02	0.00	0.06	0.01	0.17	0.27	0.37	0.27	0.04	0.09	0.08	0.09

Figure 4 long-term density estimates for key species from sites surveyed each year. Mean estimates shown for each species (mean estimate of pike and chub overlie each other).

Perch

- Perch density in 2019 (0.15 fish / 100 m^2) is less than half of the long-term mean: 0.34 fish / 100 m^2
- Peak perch density, recorded in 2017 (1.44 fish / 100 m^2) is almost a magnitude higher than the latest (2019) estimate
- Density estimates prior to and after the peak highlighted in 2017 are consistent, varying between 0.1 and 0.59 fish / 100 m^2 (± 15% of long-term mean)
- Peaks in perch density are recorded in 2004, 2010 and 2017.
- The 2019 density estimate is one of the 3 lowest estimates recorded. The other 2 occurred in 2006 (0.16 fish / 100 m^2) and 2012 (0.10 fish / 100 m^2).
- Perch density increased for 4 and 5 years respectively after 2006 and 2012; the 2 years when lowest estimates occurred, highlighted above

Trout

- Trout density estimate in 2019 (0.18 fish / 100 m^2) is very close to the long-term mean of 0.19 fish / 100 m^2)

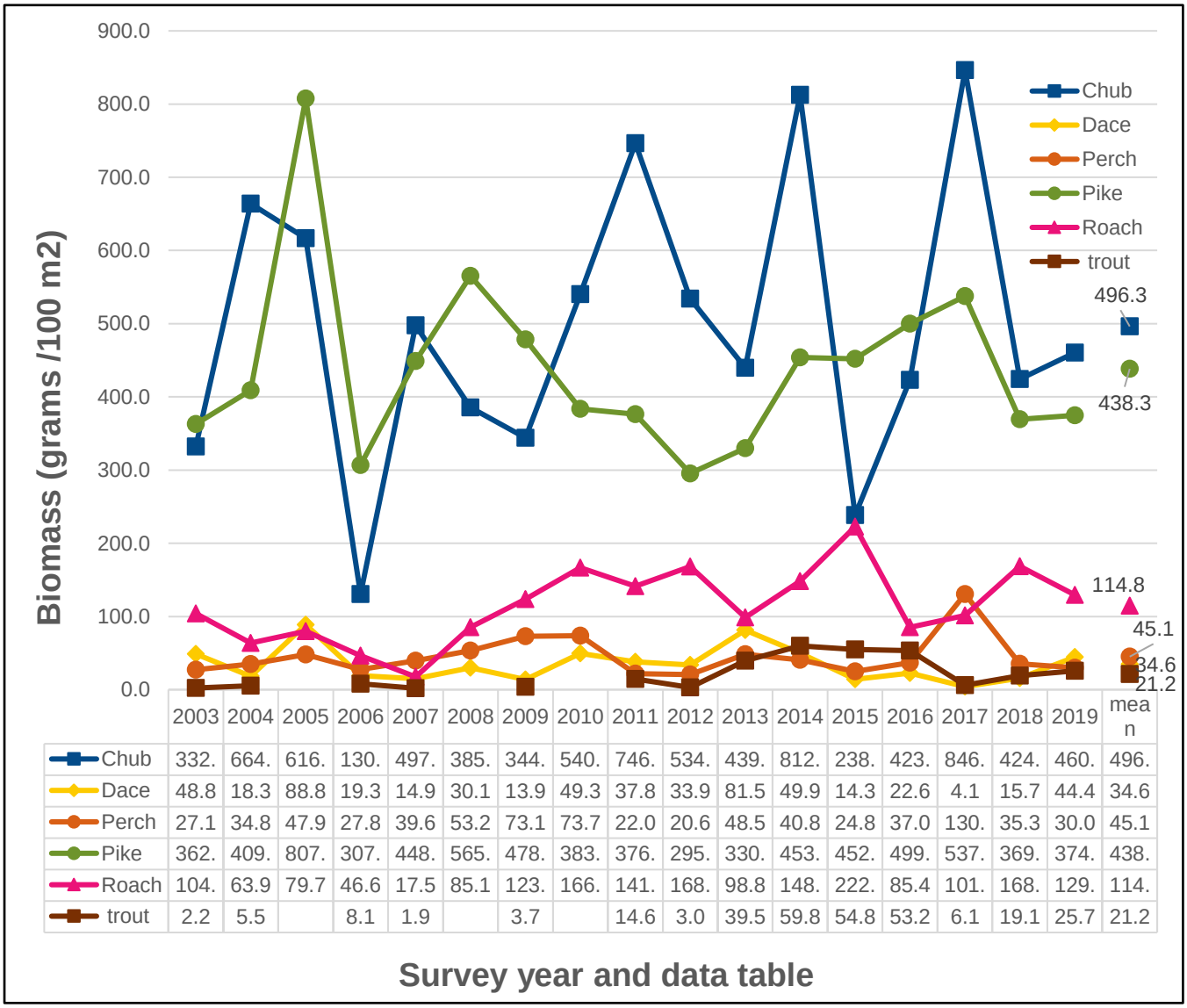
- In the central section of the River Wensum trout density rarely exceeds 0.1 fish / 100 m^2.
- Long-term records show the highest numbers of trout captured reside in sites furthest upstream
- A significant rise and fall in trout density is apparent between 2012 to 2017 with an upsurge in values from 2012, peak in 2015 (0.37 fish / 100 m^2) and decline over the next 2 years to previous levels
- As per the previous year (2018), a confirmed sea trout (identified by scale analysis) featured in the 2019 survey results.

Long-term biomass estimates

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

Roach

- Roach biomass estimate of 129.2 grams / 100 m^2 recorded in 2019 is higher than the long-term mean (114.8 grams / 100 m^2)
- The 2019 roach biomass estimate is 7.5 times higher than the lowest biomass estimate, recorded in 2007 (17.5 grams / 100 m^2)
- A significant peak in roach biomass (222.7 grams / 100 m^2) is evident in 2015 that coincides with a peak in density (see figure 4).
- Peaks in biomass estimate are evident in 2012, 2015 and 2018; troughs are apparent the year after a peak (2013, 2016 and 2019). A similar pattern exists in density estimates (See figure 4)
- Roach biomass shows an upward trend, gradually increasing over the 2003 ~ 2019 period.
- Roach biomass has remained above 85 grams / 100 m^2 since 2008



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	mean
Chub	332.	664.	616.	130.	497.	385.	344.	540.	746.	534.	439.	812.	238.	423.	846.	424.	460.	496.
Dace	48.8	18.3	88.8	19.3	14.9	30.1	13.9	49.3	37.8	33.9	81.5	49.9	14.3	22.6	4.1	15.7	44.4	34.6
Perch	27.1	34.8	47.9	27.8	39.6	53.2	73.1	73.7	22.0	20.6	48.5	40.8	24.8	37.0	130.	35.3	30.0	45.1
Pike	362.	409.	807.	307.	448.	565.	478.	383.	376.	295.	330.	453.	452.	499.	537.	369.	374.	438.
Roach	104.	63.9	79.7	46.6	17.5	85.1	123.	166.	141.	168.	98.8	148.	222.	85.4	101.	168.	129.	114.
trout	2.2	5.5		8.1	1.9		3.7		14.6	3.0	39.5	59.8	54.8	53.2	6.1	19.1	25.7	21.2

Figure 5 long-term C&S biomass estimates for key species from sites surveyed each year. Mean values shown for each species.

Dace

- Dace biomass estimate for 2019 is 44.8 grams / 100 m^2; almost 10 grams / 100 m^2 higher than the long-term average for the species**.**
- The 2019 biomass estimate is a slight decrease from the initial 2003 estimate of 48.8 grams / 100 m^2
- Dace biomass is relatively stable over the 16 year period
- Two significant peaks exist, the highest in 2005 (88.8 grams / 100 m^2) and another in 2013 (81.5 grams / 100 m^2). These peak values replicate peaks in density values for the same years (see figure 4).
- The 2019 dace estimate is over a magnitude higher than the lowest estimate recorded in 2017 (4.1 grams / 100 m2)
- In the 2 years since 2017, dace biomass has increased almost fourfold each year

Pike & Chub

- Pike and chub biomass dominate the survey results. Their respective long-term means of 438 and 496 grams / 100 m^2 exceed the total biomass of the 4 remaining key species.
- Chub Biomass estimates fluctuate significantly in a near 3 yearly cycle, peaks are apparent in the years 2004, 2007, 2011, 2014 and 2017. Corresponding troughs are present in the years 2006, 2009, 2013, 2015 and 2018.
- Chub biomass estimates show an upward trend over the period however; large fluctuations are apparent. Peak estimate is evident in 2017 (846 grams / 100 m^2) while lowest estimate is recorded in 2006 (130 grams / 100 m^2).
- Pike biomass does not exhibit such large fluctuations as that of chub. Peak estimate in 2005 is 807 grams / 100 m2. Lowest estimate in 2012 is 212 grams / 100 m^2
- Despite fluctuations pike biomass over the survey period is relatively stable although there is an apparent gradual downward trend over the longer term.
- No apparent correlation between predator and prey exists for pike or chub and the remaining key species.

Perch

- The 2019 perch biomass estimate (30 grams /100 m^2) is two thirds of the long-term mean estimate of 45 grams / 100 m^2.
- With one exception, perch biomass is relatively stable; fluctuating between 20 and 75 grams / 100 m^2 over the 16-year period. The exception being 2017 when biomass estimate is 130.6 grams / 100 m^2.
- For a period of 7 years between 2003 to 2010, a gradual upward trend in biomass estimate is indicated before estimates decrease to their lowest estimates in 2011 & 2012 (22 and 20.6 grams / 100 m^2 respectively).
- From 2011 to 2016 perch biomass estimate remained below the long-term mean estimate of 45.1 grams / 100 m^2
- Since peaking in 2017, perch biomass has reduced to the present 2019 value.

Trout

- Trout biomass estimate (25.7 grams / 100 m^2) recorded in 2019 is above the long-term mean biomass estimate of 21.2 grams / 100 m^2.
- Trout captures and therefore biomass fluctuate over the survey period.
- Trout over 99 mm FL are absent from the catch results in 2005, 2008 & 2010
- Trout biomass is above 15 grams / 100 m^2 for 7 of the 13 years they are recorded
- Trout biomass increases from 3 grams /100 m^2 in 2012 to a peak in 2014 (59.8 grams / 100 m2) with a plateau evident until 2016 before decreasing to a value of 6.1 grams / 100 m^2 in 2017
- Since 2017 trout biomass has increased more than fourfold to the 2019 value of 25.7 grams / 100 m^2.

Site level results.

The following section studies long-term trends in density and biomass estimates for key species at each temporal site based on capture records from the site. There are a number of barriers spanning the River Wensum, most restrict free movement of fish. Each survey site is isolated above and below its location by barriers; that said each 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. The

furthest upstream site within the Central section of the river Wensum is D/S Gt. Ryburgh Bridge; the furthest downstream site is Hellesdon Road, Alberts.

D/S Gt. Ryburgh Bridge

The furthest upstream site in the central section of the River Wensum is D/S Gt. Ryburgh Bridge (see figure 1 & table 2). Prior to 2013, hydro-morphology at the site comprised a straightened, uniformly trapezoidal channel, over wide of almost constant depth, limited riparian vegetation and few overhanging trees. Substrate consisted mainly of sand and silt with little gravel visible. In stream macrophyte were abundant but species limited. Surveyed area varied between 2003 ~ 2013; smallest area surveyed in 2012 was 140 m^2 due to the now bunded site and extensive weed growth. Survey area for the remaining 9 years exceeded 900 m^2 with a maximum survey area of 1460 m^2.
In late 2012 as part of the River Wensum restoration, reconnection of the river to the still visible original sinusoidal channel occurred. Riparian planting of native trees to provide shade and cover along with native plants was included in the restoration scheme. An earthen bund disconnected the previous modified, straightened river channel at the upstream end.
To allow for potential issues preventing access to an original site, Environment Agency codes of practice allow a site to be "moved" a distance of 150 metres. With this in mind, and to maintain continuity at this site, 150 metres of the newly connected channel and 37 metres of the original site now constitute the site at D/S Gt. Ryburgh Bridge. Since 2013, the survey area remains stable at 1312.5 m^2. Hydro morphology at the site now comprises riffles, pools and glides of varying depths along with naturally occurring sand, silt and gravel substrates. Diverse beds of in stream macrophytes are present along with higher species abundance. Riparian trees, planted at the time of the works are now starting to provide shade and cover. Bankside plants are re-establishing to form overhanging habitat.

Table 3: Species list and actual numbers recorded in 2019 survey at D/S Gt. Ryburgh Bridge site. Total number and number of fish over 99 mm FL shown. Survey area 1312.5 m^2 (175m x 7.5m).

Species	Total Number recorded	Number of fish over 99 mm FL
Stickleback	3	0
lamprey	8	8
Trout	4	4
Bullhead	23	0
Chub	1	0
Dace	9	0
Eel	1	1
Gudgeon	42	12
Minnow	239	0
Pike	8	8
Roach	12	11
Rudd	2	1
Stone loach	26	2

Thirteen species are recorded at this site in 2019 (table 3). Historic captures at this site include 2 additional species (perch & tench); both are absent from the 2019 captures. The absence of tench could be due to the changed hydro morphology (faster pace and less silt) since reconnecting the original river channel. The faster current may not be to their liking.

Important smaller indicator species (bullhead, gudgeon, lamprey, minnow, stickleback and stone loach) are present at this site in 2019. Records for all 6 species exist on nearly every survey since 2003 to date.

Of the smaller species, gudgeon were the first to benefit from the channel reconnection, their number jumping to a peak value of 132 fish recorded in 2013. Numbers have since dropped but gudgeon are still abundant. Dace and minnow also responded well in 2013 records with 132 dace and over 250 minnow captured. Nine dace records exist in 2019, not too surprisingly; all are less than 99 mm FL. Large dace are rare. Fish over 160 mm FL are specimen sized. Dace growth rate throughout the River Wensum falls below the national average for the species; the 9 individuals less than 99 mm FL recorded in 2019 indicate recruitment and spawning success at this site. The 2018 records show that 24 dace were caught of which 7 were over 99 mm FL.

Long-term density at D/S Gt. Ryburgh Bridge survey site

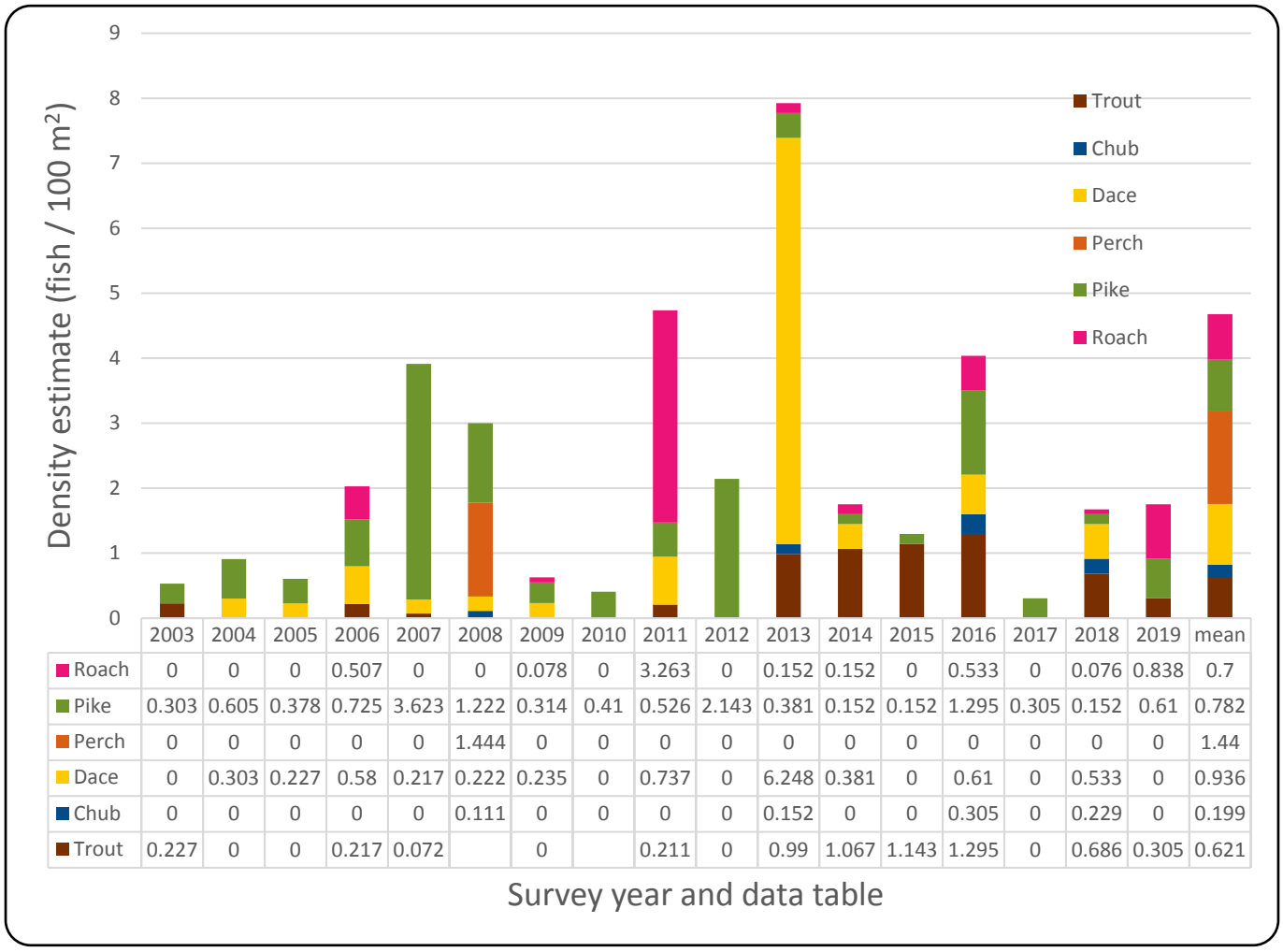
Observations: long-term density **(figure 6)**

Roach

- The 2019 roach density: 0.8 fish / 100 m^2 is above the site long term mean (0.7 fish / 100 m^2)
- Roach over 99 mm FL at this site are sporadic; recorded in 8 of the 17 surveys. 5 of those surveys where roach are present occur from 2013 to date
- The highest density recorded in 2011 (3.2 fish / 100 m^2) coincides with a reduced survey area for that year (950 m^2)

Dace

- Although dace greater than 99 mm FL are absent from the 2010, 2012, 2015, 2017 and 2019 surveys (see figure 6 & table 3) they are present every year at this site.
- Scale analysis of present and historic captures indicates a mixture of year classes with no discernible cycle evident.
- Peak density; 6.24 fish / 100 m^2 recorded in 2013 coincides with the first survey since reconnecting the original river channel.
- Long-term mean dace density is 0.9 fish / 100 m^2 however; this estimate drops to 0.4 fish / 100 m^2 if omitting the 2013 estimate.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	mean
Roach	0	0	0	0.507	0	0	0.078	0	3.263	0	0.152	0.152	0	0.533	0	0.076	0.838	0.7
Pike	0.303	0.605	0.378	0.725	3.623	1.222	0.314	0.41	0.526	2.143	0.381	0.152	0.152	1.295	0.305	0.152	0.61	0.782
Perch	0	0	0	0	0	1.444	0	0	0	0	0	0	0	0	0	0	0	1.44
Dace	0	0.303	0.227	0.58	0.217	0.222	0.235	0	0.737	0	6.248	0.381	0	0.61	0	0.533	0	0.936
Chub	0	0	0	0	0	0.111	0	0	0	0	0.152	0	0	0.305	0	0.229	0	0.199
Trout	0.227	0	0	0.217	0.072		0		0.211	0	0.99	1.067	1.143	1.295	0	0.686	0.305	0.621

Figure 6 Long-term density estimates 2003 ~ 2019 for 6 key species over 99 mm FL at D/S Gt Ryburgh Bridge survey site

Chub

- Chub density is minimal at this site being recorded in 5 of the 18 surveys
- Over the 16-year period 13 chub are recorded, 3 of the 13 measure less than 99 mm FL.
- Peak density is recorded in 2016 at 0.3 fish / 100 m^2 which is 50% higher than the long-term mean of 0.2 fish / 100 m^2
- Lowest density estimate of the 5 surveys is 0.1 fish / 100 m^2

Pike

- Pike are represented in all surveys between 2003 ~ 2019
- The 2019 density estimate of 0.6 fish / 100 m^2 is 25% below the long term mean of 0.79 fish / 100 m^2

- In 2010, 12 and 17, pike are the only species represented on the chart (figure 6). They are the only key species over 99 mm FL present
- Peak density estimate occurs in 2007. An estimate of 3.6 fish / 100 m^2 is recorded
- Up to 2013, pike density is the highest of the 5 species shown.

Trout

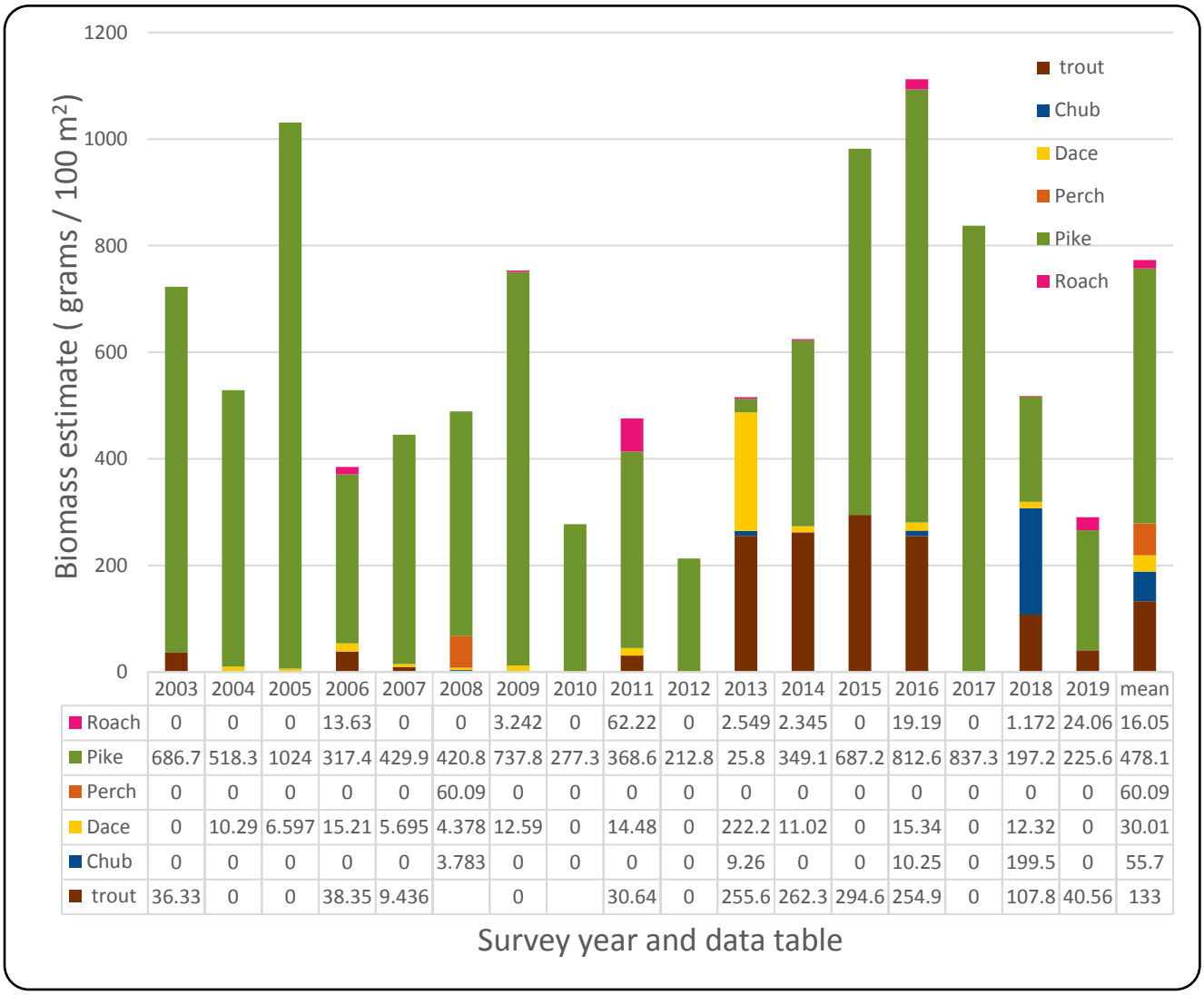
- Trout are represented in 10 of the 16 surveys; recorded in 4 surveys up until 2012, and in 6 surveys since
- The 2019 density estimate: 0.3 fish / 100 m^2 is below the long-term site mean: 0.62 fish / 100 m^2
- Trout are captured in only 4 of the 10 surveys prior to 2013; they are recorded in 6 of the 7 surveys since reconnection of the original channel in 2013
- Pike and trout densities at the site appear to be dependant variables with increases in one decreasing the other. Habitat and flow regime may be a deciding factor (see figure 7)

Long-term biomass at D/S Gt. Ryburgh Bridge survey site

Observations: long-term biomass **(figure 7)**

Roach

- The 2019 roach biomass: 24 grams / 100 m^2 shown is above the long term mean:16 grams / 100 m^2)
- Both density (see figure 6) and biomass estimates for roach over 99 mm FL peak in 2011 at this site; 3.2 fish / 100 m^2 & 62 grams / 100 m^2 respectively
- Roach are present in 8 of the 17 surveys. 5 of the surveys where roach are present occur from 2013 to date
- The highest roach biomass in 2011 (62 grams / 100 m^2) coincides with a reduced survey area for that year (950 m^2)



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	mean
Roach	0	0	0	13.63	0	0	3.242	0	62.22	0	2.549	2.345	0	19.19	0	1.172	24.06	16.05
Pike	686.7	518.3	1024	317.4	429.9	420.8	737.8	277.3	368.6	212.8	25.8	349.1	687.2	812.6	837.3	197.2	225.6	478.1
Perch	0	0	0	0	0	60.09	0	0	0	0	0	0	0	0	0	0	0	60.09
Dace	0	10.29	6.597	15.21	5.695	4.378	12.59	0	14.48	0	222.2	11.02	0	15.34	0	12.32	0	30.01
Chub	0	0	0	0	0	3.783	0	0	0	0	9.26	0	0	10.25	0	199.5	0	55.7
trout	36.33	0	0	38.35	9.436		0		30.64	0	255.6	262.3	294.6	254.9	0	107.8	40.56	133

Figure 7 Long-term biomass estimates 2003 ~ 2019 for 6 key species over 99 mm FL at D/S Gt Ryburgh Bridge survey site

Dace

- Peak biomass estimate; 224 grams / 100 m^2 recorded in 2013 coincides with the first survey since reconnecting the original river channel
- Excluding the 2013 estimate. dace biomass estimates rarely exceed 15 grams / 100 m2 at this site
- Long-term mean dace biomass estimate is 55 grams / 100 m^2.

Chub

- Despite low numbers (only 13 individual chub represent the species at this site), their long-term mean biomass is 55 grams / 100 m^2, a value that equals the long term mean of dace
- Chub are not represented in the 2019 survey results (see table 3 & figure 6)
- The 2018 peak biomass estimate: 199 grams / 100 m^2 is the highest of any species for that year
- Chub biomass in 2016 is 10 grams / 100 m^2 despite peak density recorded in that year (see figure 6)
- Lowest biomass estimate: 3 grams / 100 m2 is recorded in 2008

Pike

- Excepting 2013 & 2018, pike biomass is the highest of all species
- Pike biomass in 2019 is 225 grams / 100 m^2; just over half of the long term mean estimate: 399 grams / 100 m^2
- Mean pike biomass estimate for the period 2003 to 2012 is almost the same as mean biomass estimate for the period 2013 ~ 2019 (499 and 447 grams / 100 m^2 respectively)
- Peak biomass estimate occurs in 2005: 1024 grams /100 m^2. Pike density in 2005 is 0.3 fish / 100 m^2 (see figure 6)

Trout

- The 2019 biomass estimate (41 grams / 100 m2) is a third of the long-term mean estimate: 123 grams / 100 m^2
- Trout biomass estimates have increased significantly since 2013 after reconnecting the original channel
- Trout biomass for the four years following reconnection of the original channel (2013 ~ 2016) varies between 2 and 2.4 times the long term mean (255 ~ 295 grams / 100 m^2)

Comments / interpretation

The lack of overhanging trees and vegetation at this site prior to and after reconnection of the original channel is not favourable for chub. The faster flow regime hampers their predatory strategy and the lack of cover renders smaller chub prone to predation. Over time, as the newly planted trees establish providing cover and shade it is expected that numbers of chub, their biomass and overall size will increase.

Unlike chub, pike use their burst speed and camouflage to good effect to capture prey. Their predatory strategy is almost independent of flow regime. Pike camouflage markings avoid the need for tree cover and shade to aid ambush strategies, allowing them instead to hide in the now abundant weed and enable successful capture of prey and subsequent growth. Since 2013 juvenile pike are scarce at this site, consequently, pike density has declined; biomass however has not, indicating fewer but larger pike (See figure 6 & 7).

Trout and dace both require ample quantity of good quality water to survive. Both are recorded prior to reconnection of the original river channel. The higher densities and biomass of both species since 2013 (figure 6 & 7) indicate that habitat enhancements favour their lifestyle with spawning and refugia benefitting them above other species. Historic and more recent scale analysis of both species indicate a mixture of year classes are present and growth rate for both is fast compared to national metrics. No confident explanation is available for the decline in density and biomass for both species since 2016. Both however commonly feature in the diet of pike, which are getting bigger (see above).

Roach have yet to benefit fully from the newer site conditions. Their capture is more common at the site since 2013. It is likely their numbers will increase along with size, biomass and long-term survival. Their increased presence at the site supports this hypothesis.

Perch records for this site indicate perch are scarce here; they are only present in 1 of the 17 surveys. As a universal predator, they are expected at all sites along with eel and pike. Their absence in the 2019 captures affects the WFD classification. However, the fact they are unrecorded since 2013 suggests they do not like or are unable to find suitable habitats within the newly connected channel. Perch are expected to feature in future survey results as the changing hydro-morphology provides suitable habitat for them.

Swanton Morley

Survey site characteristics

Swanton Morley is the next site surveyed when moving downstream. It is an established site. Active fishing clubs control the fishing rights on left and right hand banks.

There are 2 mill structures between D/S Gt Rybugh Bridge and Swanton Morley site. A further 2 structures span the river downstream of Swanton Morley.

The survey site includes numerous glide and pool features. Depth varies longitudinally and across the river width throughout the 200-metre survey length. There is a moderate bend approximately a third of the way down from the top stop net where silt accumulates in the slower flow inside the bend while the outside of the bend is kept clear showing gravel substrate . Established willow trees overhang the water in places, deep water adjacent to undercut banks along with swept shallows are present. In 2019 and the years immediately prior, scarce macrophytes were visible in the water column at the time of survey. Substrate is mainly sand with gravel and silt present. Large lumps of the clay bank, riddled with crayfish burrows are visible in places in the margins. The clay lumps remain in situ until eroded away by the flow.

Table 4: Species list and captures recorded in 2019 survey at Swanton Morley site. Total number and number of fish over 99 mm FL shown. Survey area 2200 m^2 (200 m x 11 m).

Species	Total Number recorded	Number of fish over 99 mm FL
Lamprey	1	1
Trout	2	2
Bullhead	1	0
Chub	10	9
Dace	8	4
Eel	1	1
Gudgeon	28	11
Minnow	157	0
Perch	9	9
Pike	10	9
Roach	32	22
Stone loach	2	0

Survey area has remained the same (2200 m^2) since 2009. Initially as a spatial site, surveys took place on a 3 yearly schedules ie 2003, 2006 & 2009. Since 2009, the site became a temporal site, surveyed annually.

261 fish comprising 12 species are evident in the 2019 survey. Historic records for 4 other species exist for this site: bream, rudd, stickleback and tench. Of the 261 fish, 69 are greater than 99 mm FL. This includes 100% of the perch recorded; 90% of both chub and pike and surprisingly, over a third of the gudgeon (see table 4).

Smaller indicator species (bullhead, lamprey, minnow stickleback and stone loach) are present, as are eel. Two brown trout are recorded, both over 99 mm FL. The absence of tags suggests both are native bred. The number of minnow recorded is, as always, an underestimate. So too bullhead, stickleback and stone loach this is because where high numbers of small species are encountered electric fishing method sample a small proportion of their population due to limitations of the method to avoid harm to them and larger fish.

Long-term density at Swanton Morley survey site

Observations: long-term density **(figure 8)**

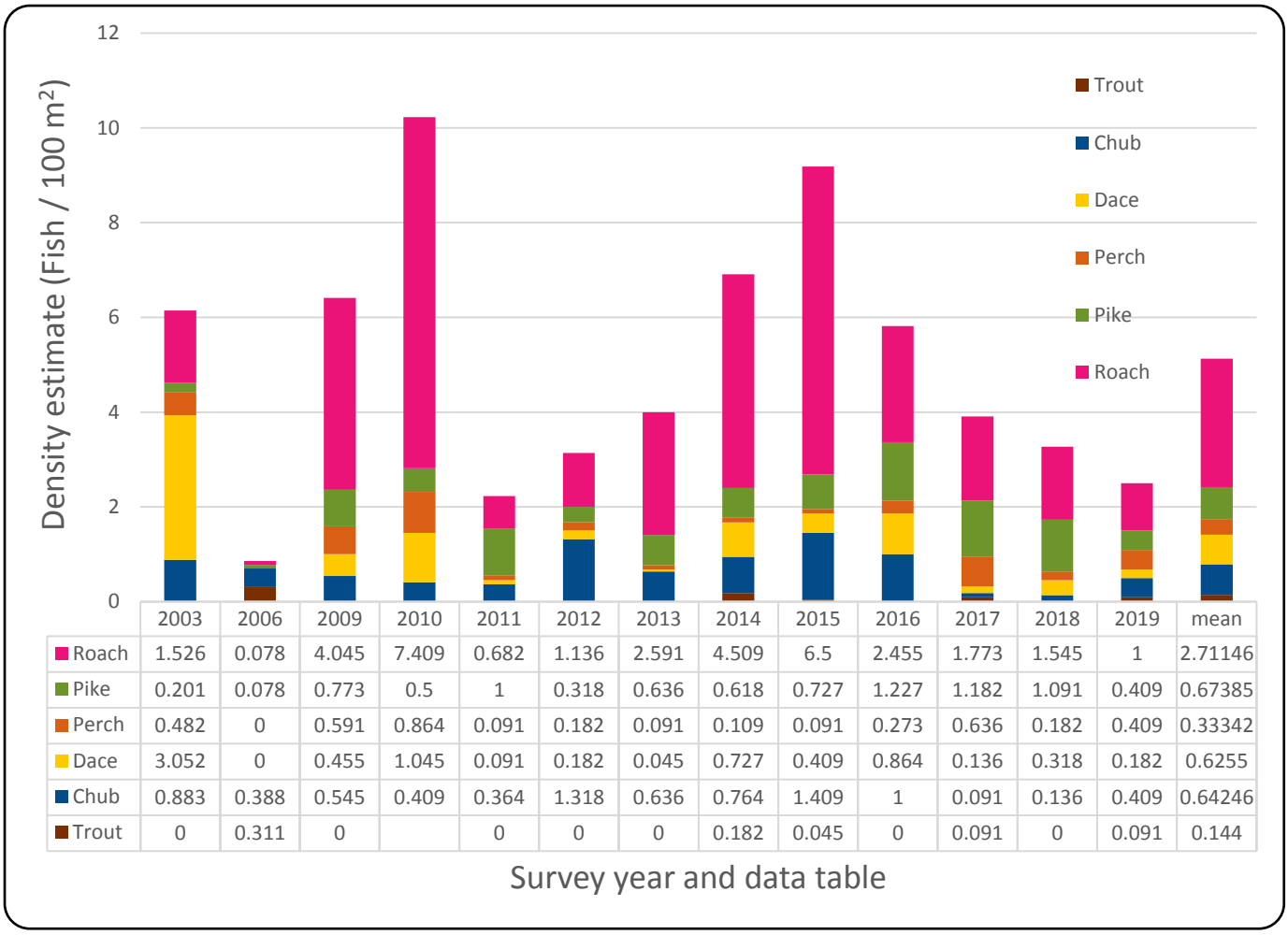
Roach

- The 2019 roach density: 1 fish / 100 m^2 is below the long-term mean (2.7 fish / 100 m^2)
- Roach captures of fish over 99 mm FL exist for every survey
- The highest density estimate in 2010 (7.4 fish / 100 m^2), is almost 3 times the site long-term mean estimate of 2.7 fish / 100 m^2
- Roach density estimate in 2011: 0.7 fish / 100 m2, is significantly lower than the peak estimate observed in 2010.

Dace

- Density estimate for dace in 2019 (0.18 fish / 100 m2) is less than the site long-term mean (0.6 fish / 100 m2)
- Dace density estimates for fish over 99 mm FL show no apparent cycle or long term trend at this site.

- No dace over 99 mm FL are recorded in 2006 for this site which prevents a calculation of density estimate and its inclusion on the chart for that year; however, dace are recorded every year at this site. 29 dace below 99 mm FL are recorded for the site in 2006.
- Scale readings indicate a healthy mixture of year classes with no discernible cycle evident.
- Peak density: 3.1 fish / 100 m^2 is recorded in 2003.



	2003	2006	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	mean
Roach	1.526	0.078	4.045	7.409	0.682	1.136	2.591	4.509	6.5	2.455	1.773	1.545	1	2.71146
Pike	0.201	0.078	0.773	0.5	1	0.318	0.636	0.618	0.727	1.227	1.182	1.091	0.409	0.67385
Perch	0.482	0	0.591	0.864	0.091	0.182	0.091	0.109	0.091	0.273	0.636	0.182	0.409	0.33342
Dace	3.052	0	0.455	1.045	0.091	0.182	0.045	0.727	0.409	0.864	0.136	0.318	0.182	0.6255
Chub	0.883	0.388	0.545	0.409	0.364	1.318	0.636	0.764	1.409	1	0.091	0.136	0.409	0.64246
Trout	0	0.311	0		0	0	0	0.182	0.045	0	0.091	0	0.091	0.144

Figure 8 Long-term density estimates 2003 ~ 2019 for 6 key species over 99 mm FL at Swanton Morley survey site. Note survey schedule changed from 3 yearly to annual surveys in 2009.

Chub

- Chub density estimate in 2019 (0.4 fish / 100 m^2) is 65% of the long-term mean for the site (0.63 fish / 100 m^2)
- The 2019 density estimate for chub at this site is indicative of increasing numbers of chub over 99 mm FL for the last 2 years at the site.
- Scale analysis shows a mixture of year classes are present across the 13 surveys
- Peak density, in 2014 is 1.4 fish / 100 m^2. The second highest density estimate occurs in 2012: 1.3 fish / 100 m^2.
- Lowest density estimate of 0.1 fish / 100 m^2 is barely discernible on the chart in 2017

Perch

- Perch density estimate; 0.4 fish / 100 m2, recorded in 2019 is higher than the site long-term mean 0.33 fish / 100 m2.
- In 2010 perch density estimate is at its highest value: 0.86 fish / 100 m^2: over twice the long-term site mean
- Perch density estimates at the site are erratic, showing no discernible pattern across the 13 surveys

Pike

- Pike are represented in every survey between 2003 ~ 2019
- The 2019 density estimate of 0.4 fish / 100 m^2 is 57% of the long term site mean: 0.7 fish / 100 m^2
- Pike density estimates show reduced numbers at the site for the last 4 years since then last peak in 2016
- There is no discernible pattern evident in pike density estimates over the 13 surveys

Trout

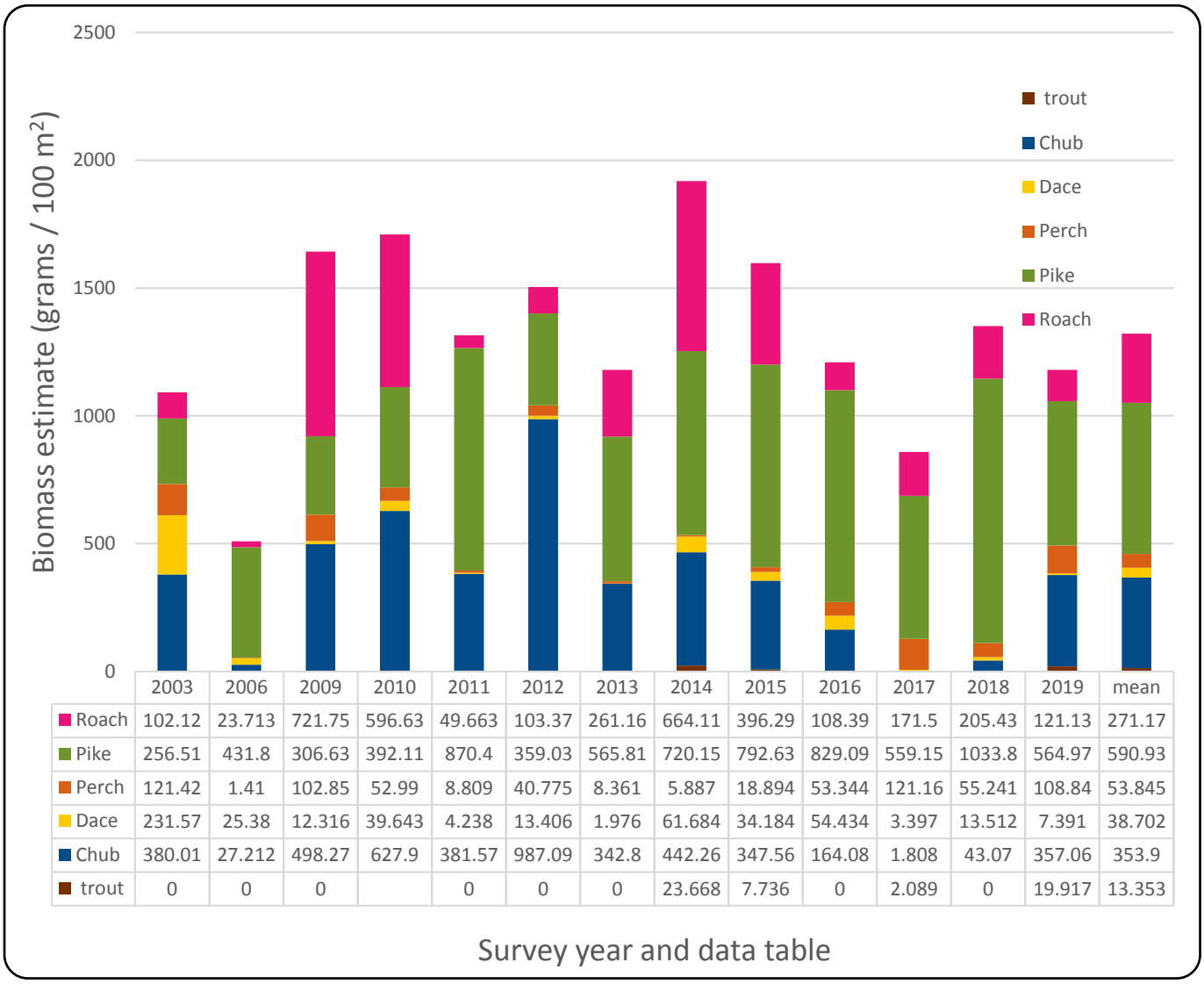
- Trout are represented in 5 of the 13 surveys and are present in the 2019 survey
- The 2019 density estimate: 0.1 fish / 100 m^2 falls short of the long-term site mean: 0.14 fish / 100 m^2
- Trout captured at the site are often identified as stocked fish, highlighted by the number of fin clipped or tags observed.

Long-term biomass at Swanton Morley survey site

Observations: long-term biomass **(figure 9)**

Roach

- The 2019 roach biomass: 121 grams / 100 m^2 shown is below the long term mean: 271 grams / 100 m^2)
- Both density (see figure 8) and biomass estimates (figure 9) for roach over 99 mm FL are highest in 2009, 2010, 2014 & 2015. Density estimates for the years mentioned are, in all cases above 4.5 fish / 100 m^2: biomass estimates remain above 400 grams / 100 m^2 for the same years.
- Biomass estimate is highest in 2009 at 721 grams / 100 m^2



	2003	2006	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	mean
Roach	102.12	23.713	721.75	596.63	49.663	103.37	261.16	664.11	396.29	108.39	171.5	205.43	121.13	271.17
Pike	256.51	431.8	306.63	392.11	870.4	359.03	565.81	720.15	792.63	829.09	559.15	1033.8	564.97	590.93
Perch	121.42	1.41	102.85	52.99	8.809	40.775	8.361	5.887	18.894	53.344	121.16	55.241	108.84	53.845
Dace	231.57	25.38	12.316	39.643	4.238	13.406	1.976	61.684	34.184	54.434	3.397	13.512	7.391	38.702
Chub	380.01	27.212	498.27	627.9	381.57	987.09	342.8	442.26	347.56	164.08	1.808	43.07	357.06	353.9
trout	0	0	0		0	0	0	23.668	7.736	0	2.089	0	19.917	13.353

Figure 9 Long-term biomass estimates 2003 ~ 2019 for 5 key species over 99 mm FL at Swanton Morley survey site

Dace

- Estimated dace biomass in 2019 is 7.5 grams / 100 m^2: less than the long-term mean for this site (38 grams / 100 m^2)
- The 2003 biomass estimate: 231 grams / 100 m^2 significantly affects the long-term mean value at this site.
- Excluding the 2003 estimate. dace biomass estimate peaks at 62 grams / 100 m^2
- In 8 of the surveys biomass estimate does not exceed 25 grams / 100 m^2

Chub

- Estimated chub biomass in 2019 at this site is 357 grams / 100 m^2 this is on a par with the long-term site mean of 353 grams / 100 m^2
- 9 chub over 99 mm FL recorded in 2019 represent the species at this site (see table 4): density estimate is 0.4 fish / 100 m^2 (see figure 8). By calculation, each fish caught weighed on average; 890 grams (2lbs)
- The peak biomass estimate: 987 grams / 100 m^2 occurred in 2012: lowest estimate 1.8 grams / 100 m2 was recorded in 2017

Perch

- Perch biomass estimate in 2019 (108 grams / 100 m^2) is over twice the long-term site mean of 53.8 grams / 100 m^2
- Perch biomass estimate at this site peaked in 2017: 121 grams / 100 m^2
- All of the perch caught at the time of survey are over 99 mm FL (see table 4)

Pike

- Since 2013 to date pike biomass estimate is the highest of all the species shown
- Pike biomass in 2019 is 564 grams / 100 m^2; slightly lower than the long-term site mean: 590 grams / 100 m^2
- Peak biomass estimate occurs in 2018: 1033 grams /100 m^2. Pike density in 2018 is 1 fish / 100 m^2 (see figure 8)
- Lowest pike biomass estimate at this site is recorded in 2003 (256 grams / 100 m^2): lowest density estimate is recorded in 2006 (see figure 8)

Trout

- In total, 10 trout over 99 mm FL represent the species from the 4 surveys where they are recorded: 2014, 2015, 2017 & 2019. These 10 trout feed into calculating trout biomass estimates.
- The 2019 biomass estimate (19.9 grams / 100 m2) is higher than the long-term site mean: 13.3 grams / 100 m^2

Comments / Interpretation

Water quality and quantity, flow regime and diverse habitats; available at this site support the 13 fish species recorded. Within the species composition are species favoured by anglers (chub, roach, perch & pike) along with indicator species showing high water quality and quantity (dace & trout) along with habitat (bullhead & stone loach). (See table 4).

Macrophyte growth at this site is abundant early in the season reducing as the year progresses. The reduced amount of macrophyte over time and the observed lumps of holey clay in the margins indicate the presence of invasive crayfish. Signal crayfish are abundant at this site, regularly disturbed and observed throughout surveys.

Chub survive well at this site. Scale analysis shows individuals can be over 16 years old. Chub growth rate accelerates once they attain a size able to utilise the abundant crayfish at the site. The low and absent biomass estimates for chub in 2018 & 2017 is thought to be a consequence of the low flows at the time of survey giving rise to reductions in suitable habitat favoured by larger specimens.

Roach density and biomass show 4 distinct peaks; both peak in the same years 2009, 2010, 2014 & 2015. During 2009 & 2010, unwanted adult roach from the nearby trout lake were transferred to the river. In 2013 & 2014, unwanted live roach spawn removed from the nearby trout lake were transferred to the river. Capture records in the years following egg transfers and in the years that the transfer of adults took place, coincide with the highest roach numbers, density and biomass estimates recorded. Roach numbers fell in the years since transfers (see figures 8 & 9). No further egg or adult transfers have occurred since 2015. Roach numbers, density and biomass have declined since 2015 indicative of a lack of habitat or food availability at the site. However, there appears to be a 7-year cyclic pattern in density and biomass when assessed over the entire river in the long term (see figures 4 & 5).
Scale analysis indicates roach survive over 10 years at this site; they demonstrate a slow growth rate over their life span compared to national metrics (see Discussion section below).

Perch records exist most years at this site (figure 8). In 2019, Swanton Morley yielded the largest individual perch from any of the surveys (see table 1). The majority of the perch caught at this site come from near marginal rushes, under cover (below willow branches) or among the denser stands of weed present.

Marginal rush is limited along the section. Preferred habitat for rush growth is deep water with a course substrate, close to the bank. Perch ambush strategies centre on camouflage and short, fast bursts of speed. Their distinct markings camouflage them among reed stems; shade also helps to hide their presence. As prey move within reach, perch use a short fast burst of speed for capture, returning to cover if successful. In time, further marginal reed and rush growth should increase density and biomass of perch at the site.

Pike presence at this site for each survey indicates habitat for their continued existence is available. Biomass estimates indicate the presence of ample prey too. Density estimates over the long-term data set are never high however; biomass shows the small number of pike feed well. The decreasing quantity of macrophye available as the season's progress may alter feeding opportunities and strategy benefitting smaller more numerous individuals to the detriment of older, larger individuals (see figures 8 & 9).

In 2019 along with smaller indicator species, juvenile (less than 99 mm FL) roach, dace, chub and pike are present at this site (see table 4) indicating successful spawning and recruitment.

D/S Elsing Mill

Survey site characteristics

An existing mill structure upstream of the site and further barriers to migration downstream ensure that D/S Elsing Mill survey site is, like Swanton Morley, isolated. Scheduled annually, survey records exist for D/S Elsing Mill site since 2003

Limited habitat and flow regime exist at this site. Wide beds of Glycera maximus provide shaded water of modest depth along the margins. Depths vary, between 0.8 m and 2 m within the survey site.
Approximately half way along the survey site a single well-established willow projects almost across the entire width of the river. The additional scarce marginal trees observed are saplings.

Table 5: Species list and captures recorded in 2019 survey at D/S Elsing Mill site. Total number and number of fish over 99 mm FL shown. Survey area 2000 m^2 (200 m x 10 m).

Species	Total Number recorded	Number of fish over 99 mm FL
Chub	79	23
Dace	52	20
Eel	1	1
Gudgeon	174	42
Minnow	116	0
Pike	37	36
Roach	49	27

Figure 10 **Electric fishing D/S of Elsing Bridge. Top stop net in foreground. Boat based survey using two 60 cm diameter anodes: 4 crew.**

Gravels are visible on the substrate in a few places but the majority of the riverbed consists of sand and silt. In places lumps of the clay bank, riddled with holes lie atop the riverbed where they have toppled in. Signal crayfish are abundant in the survey section, some very large.

In 2019, macrophytes are visible in the water column at the time of survey (see figure 10). Survey area has varied over time at this site ranging from 1500 m^2 to over 3500 m^2. However, since 2014, survey length: 200 m and width: 10 m remain stable. 508 fish, comprising 7 species; are present in the 2019 survey. Of the 508 fish, 149 are greater than 99 mm FL (table 5 above). Historically a further 8 species of fish to those shown in table 6 are recorded from this site: bullhead, lamprey, perch, ruffe, stickleback, stone loach, tench and trout.

Apart from minnow, the smaller indicator species (bullhead, lamprey, stone loach and stickle back) along with trout are absent from the 2019 survey results.
A single eel indicates their presence at the site.

The number of minnow recorded is, as always, an underestimate (see method statement). Gudgeon numbers are likely to be underestimated too.

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

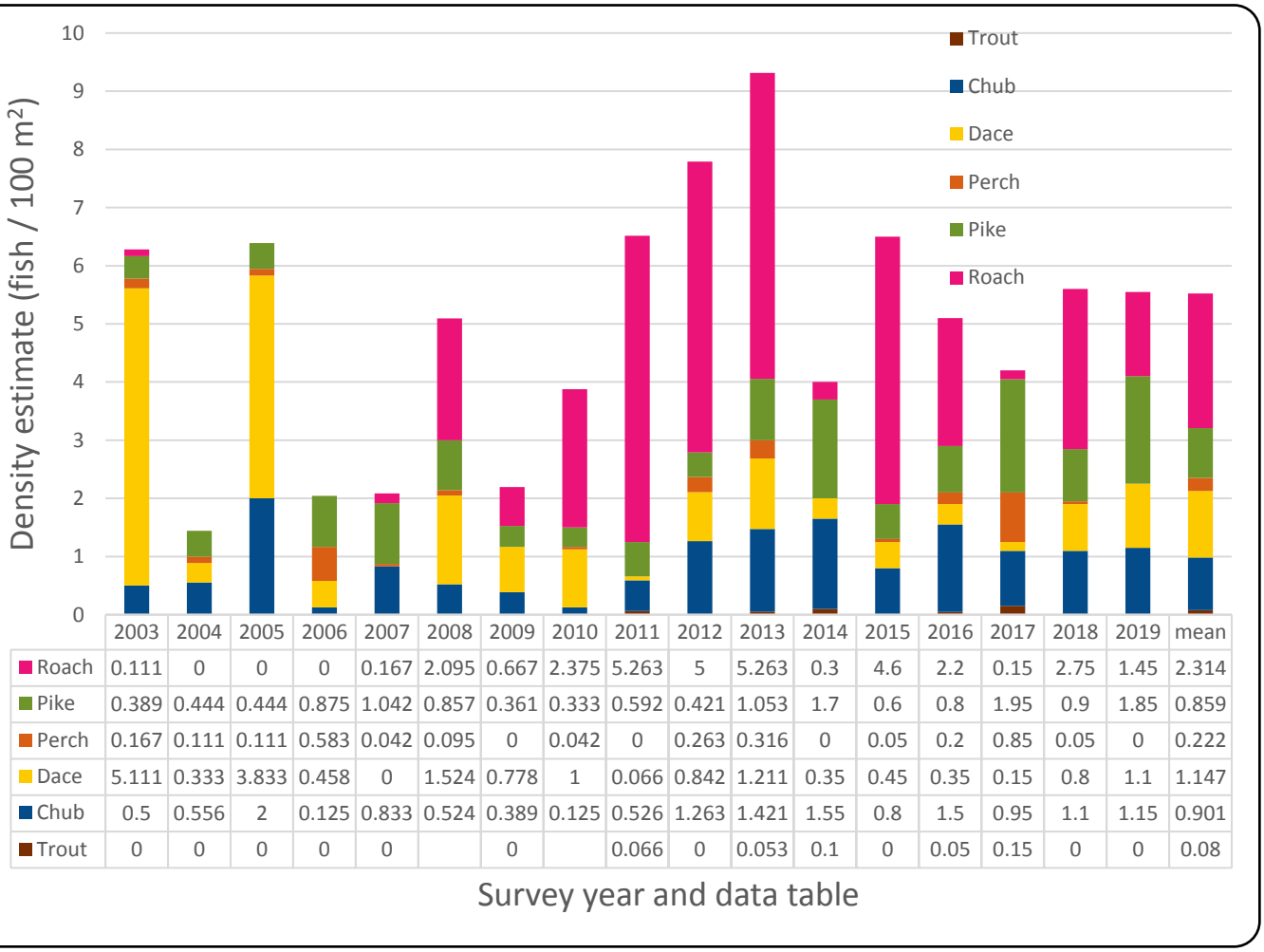
Observations: long-term density (figure 11)

Roach

- The 2019 roach density: 1.45 fish / 100 m^2 is below the long-term mean (2.3 fish / 100 m^2)
- Roach, over 99 mm FL, feature in the survey results for the last 13 years; since 2007 to date.
- The highest density estimate in 2011 (5.2 fish / 100 m^2), is almost twice the long-term site mean estimate of 2.7 fish / 100 m^2
- Roach over 99 mm FL are not recorded in 2004, 2005 & 2006.

Dace

- Density estimate for dace in 2019 (1.1 fish / 100 m^2) is on a par with the long-term site mean (1.1 fish / 100 m^2)
- There are two significant peaks in dace density estimate, the first in 2003: 5.1 fish / 100 m^2 and second in 2004: 3.8 fish / 100 m^2.
- Prior to 2007, dace density estimates are the highest of all 6 species. Since 2007, the position of roach and dace density estimates reversed: roach density estimates exceeding those of dace.
- No discernible spawning or recruitment pattern is evident over the 17-year period.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	mean
Roach	0.111	0	0	0	0.167	2.095	0.667	2.375	5.263	5	5.263	0.3	4.6	2.2	0.15	2.75	1.45	2.314
Pike	0.389	0.444	0.444	0.875	1.042	0.857	0.361	0.333	0.592	0.421	1.053	1.7	0.6	0.8	1.95	0.9	1.85	0.859
Perch	0.167	0.111	0.111	0.583	0.042	0.095	0	0.042	0	0.263	0.316	0	0.05	0.2	0.85	0.05	0	0.222
Dace	5.111	0.333	3.833	0.458	0	1.524	0.778	1	0.066	0.842	1.211	0.35	0.45	0.35	0.15	0.8	1.1	1.147
Chub	0.5	0.556	2	0.125	0.833	0.524	0.389	0.125	0.526	1.263	1.421	1.55	0.8	1.5	0.95	1.1	1.15	0.901
Trout	0	0	0	0	0		0		0.066	0	0.053	0.1	0	0.05	0.15	0	0	0.08

Figure 11 Long-term density estimates 2003 ~ 2019 for 6 key species over 99 mm FL at D/S Elsing Mill survey site.

Chub

- Chub density estimate in 2019 (1.15 fish / 100 m^2) is above the long-term mean for the site (0.9 fish / 100 m^2)
- The 2019 chub density estimate shows a gradual rise over the proceeding 2 years: 1.1 fish / 100 m^2 recorded in 2018 and 0.95 fish / 100 m^2 in 2017.

- Scale analysis shows a mixture of year classes are present at this site with some fish over 16 years old. Growth rate accelerates in chub over 4 years of age; approximately 180 mm FL. Prior to this time, growth rate is below average.
- Chub density estimates over the 17 year survey period rise and fall with no pattern apparent
- Highest density estimate, in 2005 is 2 fish / 100 m^2. The second highest density estimate occurs in 2015: 1.6 fish / 100 m^2.
- Lowest density estimates occurred in 2006 & 2010, both estimates recorded at 0.12 fish / 100 m^2

Perch

- Perch are absent from the 2019 survey. The site long-term mean for perch is 0.22 fish / 100 m^2.
- Noted in 2019, perch are absent in 2009, 2011 & 2014. Records show 7 perch under 99 mm FL captured in 2009.
- In 2017 perch density estimate is at its highest value: 0.85 fish / 100 m2.
- Perch density estimates at this site are inconsistent, showing no discernible pattern throughout the 17 surveys

Pike

- Pike are represented in all 17 surveys covering 2003 ~ 2019
- The 2019 density estimate of 1.9 fish / 100 m^2; the second highest estimate recorded, is over twice the long term site mean: 0.85 fish / 100 m^2
- After 2011, peaks in pike density estimates, although offset by a year or two seem to correspond with peaks in roach density (see figure 11)

Trout

- No trout are present at this site in 2019, of the 17 surveys, trout records exist for 5
- Long-term site mean trout density estimate is 0.07 fish / 100 m^2 based on 8 total captures
- Trout when captured at the site are native: no fin clipping is observed of those caught nor tags recorded

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

Observations: long-term Biomass estimates **(figure 12)**

Roach

- The 2019 roach biomass: 62 grams / 100 m^2 is less than half of the long term site mean:127 grams / 100 m^2)
- Biomass estimate is highest in 2015 at 380 grams / 100 m^2
- Roach biomass estimate has decreased year on year for the last 5 years

Dace

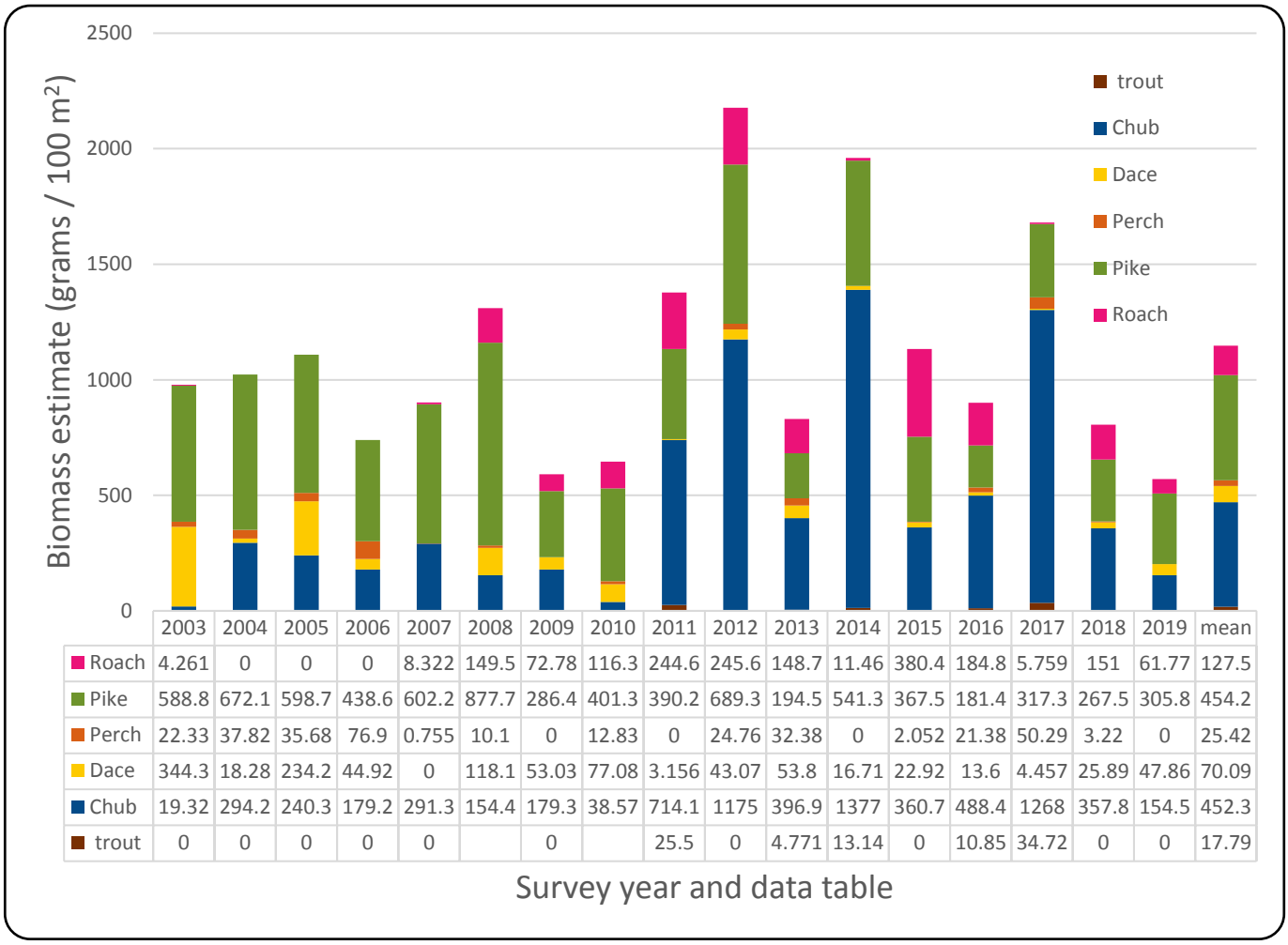
- Estimated dace biomass in 2019 is 47 grams / 100 m^2: less than the long-term site mean estimate of 70 grams / 100 m^2
- The 2003 peak biomass estimate: 344 grams / 100 m^2 is 5 times higher than the long-term mean estimate.
- Second highest biomass estimate is recorded in 2005: 234 grams / 100 m^2
- Discounting biomass estimates in 2003 and 2005 dace biomass estimates do not exceed 120 grams / 100 m^2 in any year.
- Dace are absent in 2007, aside from 2007, the lowest biomass estimate is 3 grams / 100 m^2 recorded in 2011.

Chub

- Estimated chub biomass in 2019 at this site is 154 grams / 100 m^2. The long-term site mean is 452 grams / 100 m^2.
- The peak biomass estimate: 1377 grams / 100 m^2 occurred in 2014: lowest estimate 19 grams / 100 m^2 was recorded in 2003

Perch

- Perch presence is not recorded in the 2019 survey. The long-term site mean is 25 grams / 100 m^2
- Perch biomass estimate at this site peaked in 2006: 76 grams / 100 m^2
- Perch are completely absent from 5 of the 17 surveys since 2003.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	mean
Roach	4.261	0	0	0	8.322	149.5	72.78	116.3	244.6	245.6	148.7	11.46	380.4	184.8	5.759	151	61.77	127.5
Pike	588.8	672.1	598.7	438.6	602.2	877.7	286.4	401.3	390.2	689.3	194.5	541.3	367.5	181.4	317.3	267.5	305.8	454.2
Perch	22.33	37.82	35.68	76.9	0.755	10.1	0	12.83	0	24.76	32.38	0	2.052	21.38	50.29	3.22	0	25.42
Dace	344.3	18.28	234.2	44.92	0	118.1	53.03	77.08	3.156	43.07	53.8	16.71	22.92	13.6	4.457	25.89	47.86	70.09
Chub	19.32	294.2	240.3	179.2	291.3	154.4	179.3	38.57	714.1	1175	396.9	1377	360.7	488.4	1268	357.8	154.5	452.3
trout	0	0	0	0	0		0		25.5	0	4.771	13.14	0	10.85	34.72	0	0	17.79

Figure 12 **Long-term biomass estimates 2003 ~ 2019 for 6 key species over 99 mm FL at D/S Elsing Mill survey site.**

Pike

- Between 2003 and 2010 pike biomass estimate is the highest of all the species shown
- Pike biomass in 2019 is 305 grams / 100 m^2; two thirds of the site long term mean estimate for the species 454 grams / 100 m^2
- Peak biomass estimate occurs in 2008: 877 grams /100 m^2. Pike density in 2008 is 0.85 fish / 100 m^2: the site long term mean (see figure 11)
- Lowest pike biomass estimate at this site is recorded in 2016 (181 grams / 100 m^2)

Trout

- Trout are absent in 2019. The site long-term mean is 18 grams / 100 m^2
- Trout biomass estimates are based on low numbers of trout caught at the site in the 5 surveys where they are recorded: 2011. 2013, 2014, 2016 & 2017 (8 fish in total).

Comments / Interpretation

The number of species recorded from this site (7) in 2019 (see table 5) is the lowest recorded from the 17 surveys. The absence of indicator species (trout, bullhead, lamprey, stickleback & stone loach) in 2019 suggests a lack of cover and habitat availability for them, leading to increased predation and reduced recruitment. Bullhead and stone loach number have declined since 2003. Stone loach have been absent from the capture records for the last 7 surveys; bullhead for the last 3.

The abundant signal crayfish population observed at this site could be acting as ecosystem engineers and interspecies competitors, affecting substrate composition and habitat availability.

The fine silts and sands washed from collapsed riverbank material, mentioned previously, and the moderate flow regime leads to the effective smothering of cobbles and gravels alike. Both necessary habitats for bullhead and stone loach. In addition, it is likely the large crayfish present would commandeer any uncovered cobbles again preventing their use by stone loach or bullhead.

The occasional captures of trout (see above) and regular dace captures at this site indicate good water quality and quantity. Dace below and above 99 mm FL are recorded each year from this site indicating suitable spawning habitat is available, most likely upstream at the mill. Recruitment to the dace population is ongoing; both aspects supported by scale analysis indicating dace of 6 years old exist at this site along with 6 consecutive year classes. Scale analysis also shows that dace at this site demonstrate slow growth rates compared to national metrics.

Chub survive well at this site; the flow regime, cover and food availability all contribute to their continued health and wellbeing. Like Swanton Morley, scale analysis shows individuals over 16 years old at this site and that growth rate accelerates once chub attain a size able to utilise the abundant food groups (crayfish). Density estimates since 2012 are reasonably stable while the 3 main peaks in biomass estimate occur in the years since. Water depth at this site is stable even in times of prolonged dry weather. The stable deep-water margins under spreading marginal cover suits this opportunistic predator.

Prior to 2008, dace biomass and density estimates exceed those of roach, since 2008, roach estimates exceed those of dace. Dace show a preference for fast flows and shallow water whereas roach show a preference for deeper water and slower flows. The changes observed in 2008 (see figures 11 & 12) could indicate changes in hydro-geomorphology at this site.
After 2008, roach density estimates are frequently the highest recorded of the 6 key species (see figure 11). For the last 12 years the number of roach under 99 mm FL as a percentage of the total caught never falls below 29%. In 2008, 44 roach are recorded, all are under 99 mm FL. The previous findings suggest the creation of suitable roach spawning habitat, possibly to the detriment of suitable dace spawning habitat occurred in 2008 and since. The 2019 survey results indicate 45% of the roach caught to be under 99 mm FL indicating successful spawning and recruitment in the preceding years.

Roach biomass is low in comparison to other key species (see figure 12) and the peak biomass and density estimates occur in the same years (see figures 11 & 12). This suggests most roach present at this site do stay here for long, even though scale analysis shows roach over 10 years of age exist at this site.

It is no surprise that perch are absent from the 2019 results (see table 1). As an agile, ambush, predator perch require suitable structure and habitat to use their camouflage coloration to best effect (see Swanton Morley comments interpretation section). There appeared to be a lack of suitable structure and weed growth in 2019.
Perch do however feature in 13 of the 17 surveys (see figure 11) suggesting that on those surveys, suitable structure and weed growth were present.

Pike presence at this site for all 17 surveys indicates ample prey and suitable habitat are available for them to survive. Pike are able to benefit from the lack of weed and structure at this site. Their high burst speed permits them to catch their prey and thrive at this site. Density estimates show the variation in pike spawning success and recruitment over the 17 year period (see figure 11) further supported by measurements of each individual captured (see table 1 & 4). Biomass estimates reflect the high average size of pike resident at this site (see figure 12). There is no apparent correlation between pike and a single prey species at this site. Even when roach density is at its highest (2011, 2012, 2012 & 2014) pike density and biomass are not. Density estimates over the long-term data set are never high however; biomass shows the small number of pike feed well.

In 2019 along with minnow, juvenile (less than 99 mm FL) roach, dace, chub and pike are present at this site (see table 4), however with the exception of minnows and roach, juveniles of chub, dace, perch & pike are sporadic, suggesting a lack of suitable habitat for juveniles at this site.

Sparham pool, Lyng

Survey site characteristics

Sparham pool is a recent addition to the annual survey sites on the River Wensum. Initially surveyed in 2013 to ascertain possible effects of stocked barbel on resident stocks the site now forms part of a national water resources network. Externally funded, survey take place annually. Lyng Mill effectively separates this site from the Elsing Mill survey site. Surveys took place in 2017, 2018 and 2019. Calculated survey area is 1650 m^2. A mix of hydro geomorphologic features (bends, deep narrows, wide shallows, riffle, pool, glide, silt berms, sand patches, undercut bends and gravel substrate) exist within the 150 metre survey length.

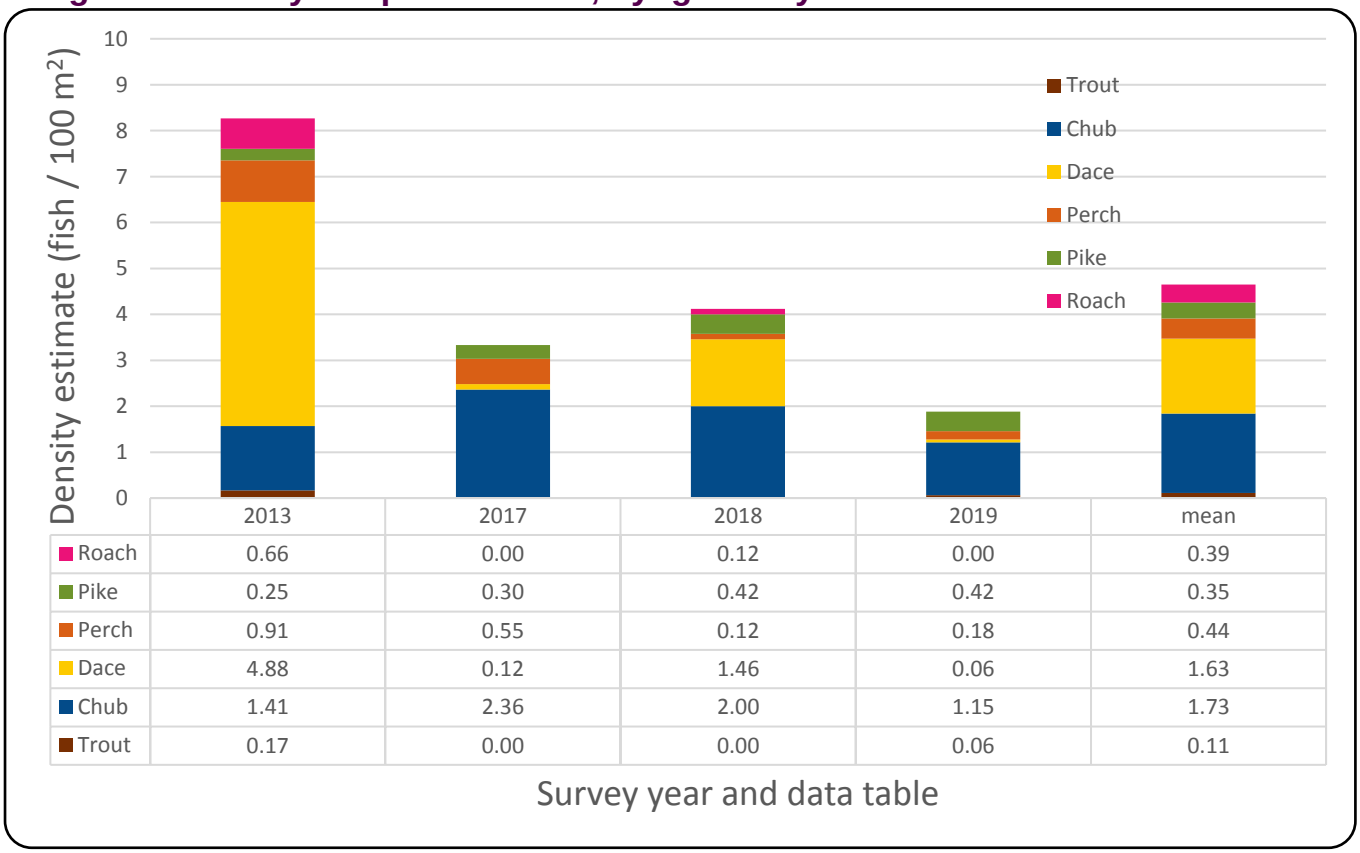
Overhanging trees with roots trailing in the water along with grass and rush grow each side of the 11 metre wide channel.
Dense stands of macrophytes grow in the river, mainly (potamogeton, callitriche, sparganium and vallis). On the gravel riffles, water crowfoot is evident.

Species	Total Number recorded	Number of fish over 99 mm FL
Lamprey	7	7
Trout	1	1
Bullhead	4	0
Chub	68	19
Dace	23	1
Eel	1	1
Gudgeon	18	9
Minnow	133	0
Perch	42	3
Pike	7	7
Roach	20	0
Tench	1	1

Table 6: Species list and captures recorded in 2019 survey at Sparham Pool, Lyng site. Total number and number of fish over 99 mm FL shown.

In total 325 individual fish, comprising 12 different species are present at Sparham pool, Lyng in 2019. Of the total number, 49 are over 99 mm FL.
In 2013, 3 more species were recorded from this site: barbel, bream and stone loach. Of the 3 additional species only stone loach maintain a presence.
Included in the catch are 4 of 6 indicator species; namely bullhead, lamprey, eel & trout. The 2019 survey sheet shows that the remaining indicator species: stickleback and stone loach are present within the survey reach but evaded capture at the time of survey. A single trout and a single tench show in the catch results. A plastic tag anchored in front of the dorsal fin indicates the trout to be a stocked fish; thought to have escaped from a nearby trout fishing lake. The tench may have escaped from a nearby fishing lake too.

Long-term density at Sparham Pool, Lyng survey site



	2013	2017	2018	2019	mean
Roach	0.66	0.00	0.12	0.00	0.39
Pike	0.25	0.30	0.42	0.42	0.35
Perch	0.91	0.55	0.12	0.18	0.44
Dace	4.88	0.12	1.46	0.06	1.63
Chub	1.41	2.36	2.00	1.15	1.73
Trout	0.17	0.00	0.00	0.06	0.11

Figure 13 Long-term density estimates for 6 key species over 99 mm FL at Sparham Pool. Lyng survey site.

Observations: long-term density (figure 13)

Roach

- Although 20 roach records exist in the 2019 survey at this site, none measure over 99 mm FL (see table 6). The site long-term mean roach density estimate is 0.39 fish / 100 m^2
- Roach density estimate is highest in 2013 at 0.66 fish / 100 m^2
- No cyclic pattern for roach density is apparent at this site

Dace

- Density estimate for dace in 2019 (0.06 fish / 100 m^2) is considerably lower than the site long-term mean estimate (1.6 fish / 100 m^2)
- Highest dace density recorded in 2013 is 4.88 fish / 100 m^2.
- Dace over 99 mm FL are recorded each year at this site.
- No cyclic recruitment pattern is evident from the chart
- Scale readings indicate a healthy mixture of year classes.

Chub

- Chub density estimate in 2019 (1.15 fish / 100 m^2) is the lowest estimate noted for the site
- The site long-term mean estimate is 1.73 fish / 100 m^2
- Chub density estimates have decreased by 50% since 2017
- Scale analysis shows a mixture of year classes are present at this site
- Highest density, in 2017 is 2.4 fish / 100 m^2.

Perch

- Perch density estimate; 0.2 fish / 100 m^2, recorded in 2019 is lower than the site long-term mean 0.44 fish / 100 m2.
- Perch are represented in all 4 surveys
- In 2013 perch density estimate is at its highest value: 0.9 fish / 100 m^2: over twice the long-term site mean
- Lowest perch density estimate occurred in 2018, dropping to 0.12 fish / 100 m^2.

Pike

- Pike are represented in all 4 surveys
- The 2019 density estimate of 0.42 fish / 100 m^2 is higher than the long term site mean: 0.35 fish / 100 m^2
- Highest pike density estimate occurs in 2019. The 2018 estimate is the same as the 2019 estimate.
- Lowest pike density occurs in 2013 (0.25 fish / 100 m^2)
- Pike density has increased since 2013

Trout

- Trout are represented in the 2013 & 2019 surveys
- The 2019 density estimate: 0.06 fish / 100 m^2 falls short of the long-term site mean: 0.11 fish / 100 m^2
- Trout captured at the site often identify as stocked fish, highlighted by fin clipping or tags.

Long-term biomass at Sparham pool, Lyng survey site

Observations: long-term Biomass estimates **(figure 14)**

Roach

- No roach over 99 mm FL were recorded in 2019 (see table 6), as such biomass estimate is not possible. The same applies for roach in 2017. However, the site long-term mean biomass estimate is 28 grams / 100 m^2 based on the 2 values available.
- Biomass estimate is highest in 2013 at 53 grams / 100 m^2
- Roach biomass estimate shows little trend or pattern over the 4 surveys to date

Dace

- Estimated dace biomass in 2019 is 0.8 grams / 100 m^2: less than 1.5% of the long-term site mean estimate of 66 grams / 100 m^2
- The highest biomass recorded occurred in 2013: 226 grams / 100 m^2 is 3.5 times higher than the long-term mean estimate.
- Dace biomass has declined since 2013.

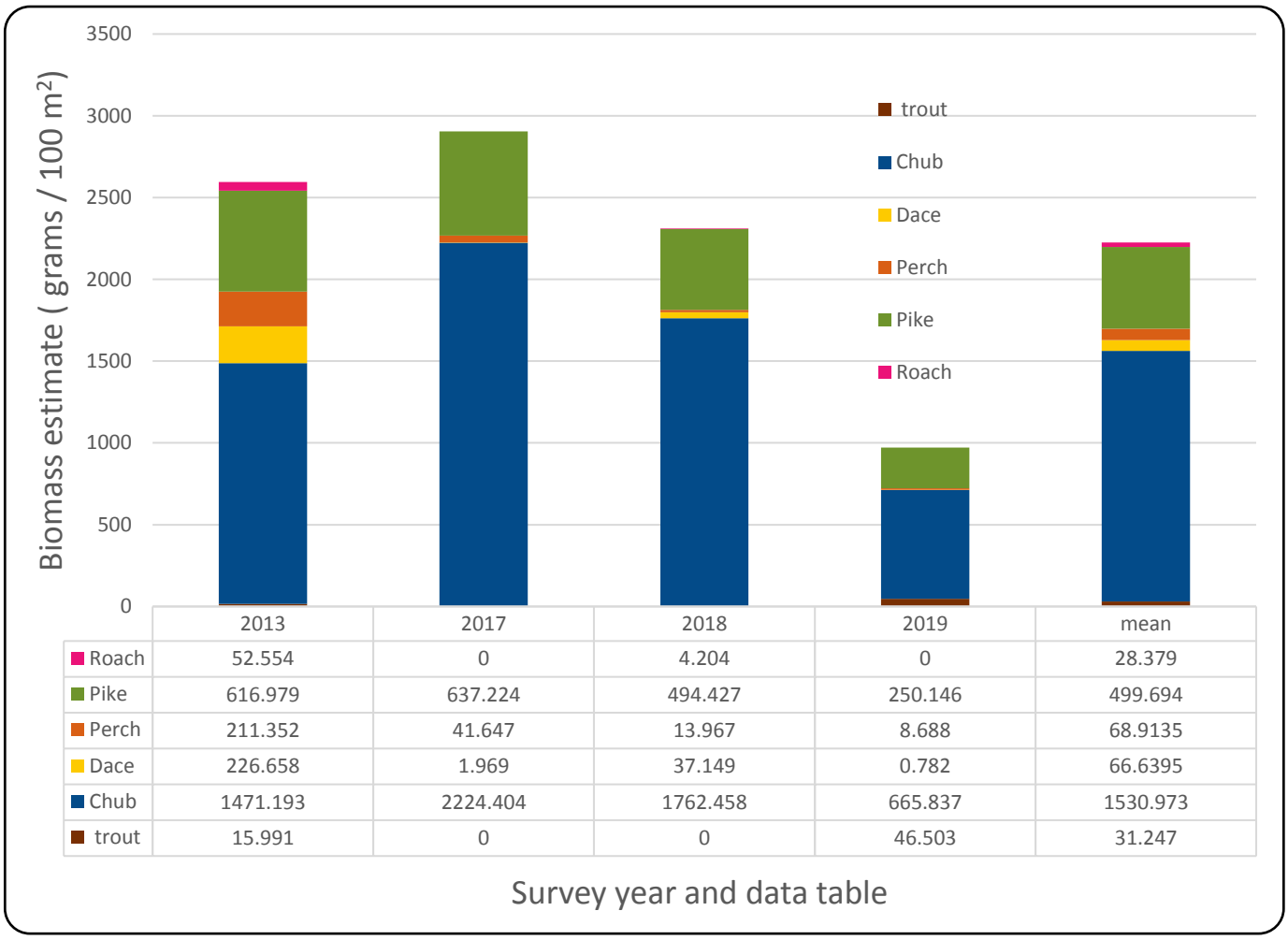
Chub

- Estimated chub biomass in 2019 at this site is 665 grams / 100 m^2. The long-term site mean is 1530 grams / 100 m^2.
- The peak biomass estimate: 2224 grams / 100 m^2 occurred in 2017: lowest biomass estimate is recorded in 2019
- Chub biomass has reduced by 60% since 2017

Perch

- Perch biomass estimate for 2019 is 9 grams / 100 m^2 significantly lower than the site long-term mean of 69 grams / 100 m^2
- Perch biomass estimate at this site peaked in 2013: 211 grams / 100 m^2

- Perch biomass has decreased dramatically since 2013.



	2013	2017	2018	2019	mean
Roach	52.554	0	4.204	0	28.379
Pike	616.979	637.224	494.427	250.146	499.694
Perch	211.352	41.647	13.967	8.688	68.9135
Dace	226.658	1.969	37.149	0.782	66.6395
Chub	1471.193	2224.404	1762.458	665.837	1530.973
trout	15.991	0	0	46.503	31.247

Figure 14 Long-term biomass estimates for 6 key species over 99 mm FL at Sparham pool, lyng survey site

Pike

- Pike biomass in 2019 is 250 grams / 100 m^2; half the value of the site long term mean estimate for the species: 499 grams / 100 m^2
- The 2019 biomass estimate is the lowest of all the 4 surveys.
- Peak biomass estimate occurs in 2017: 637 grams /100 m^2.
- For the 3 surveys (2013, 1017 & 2018) pike biomass estimates are within 25 % of the 2017 peak estimate

Trout

- Trout biomass estimate in 2019 is 47 grams / 100 m^2. The site long-term mean is 31 grams / 100 m^2
- Trout are recorded in 2 of the 4 surveys
- The 2019 trout biomass estimate derives from a single fish.

Comments / Interpretation

Robustness: The limited number of surveys at this site and subsequent lack of data affects the robustness of any trend analysis or interpretation undertaken. That said, a number of pertinent observations are made, their validity or otherwise can only be gauged over time.

Location: Liaison with local anglers prior to selecting this site, intimated this area would be the most likely to produce barbel along with established stock. Although expectations were for large specimen sized barbel, a single barbel capture recorded in 2013 measuring 253 mm FL is noted. Aged at 3+ this fish, if stocked, would have been introduced to the river around 2010~ 2011. Barbel stocked into this section of river between 2009 and 2013 had to be identifiable. Every stocked fish had a unique tag inserted. No tag is evident in the individual caught in 2013 strongly suggesting it to be a naturally bred fish.

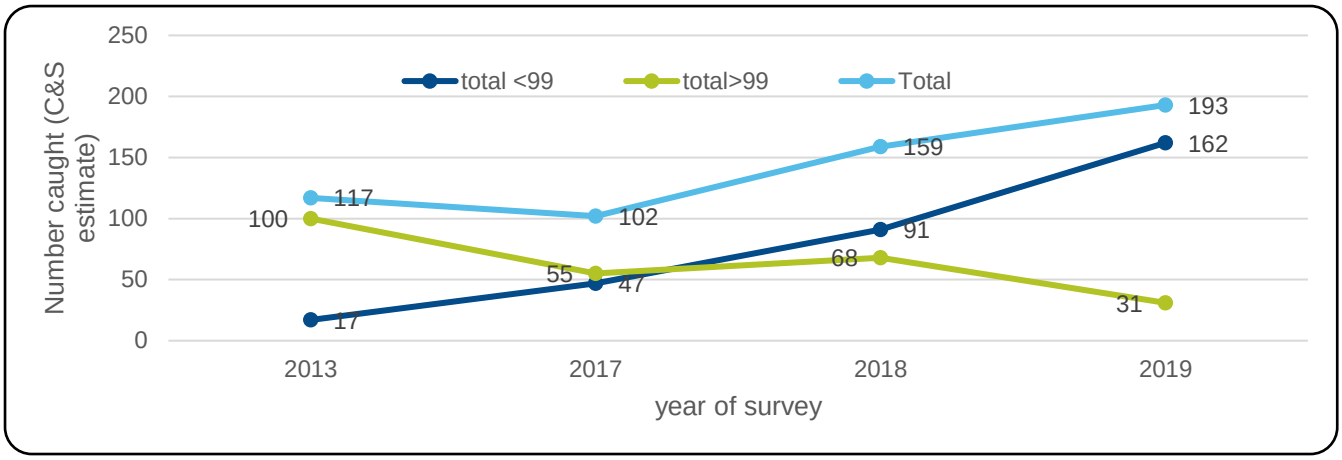


Figure 15. Total combined estimated number of fish, estimated number of fish over 99 mm FL and estimated number of fish less than 99 mm FL at Sparham pool survey site for 6 key species.

Trend interpretation: Since 2013, figures 13 & 14 indicate a decline in biomass and density estimates for 5 of the 6 species considered. That said pike density estimates show year on year increases to date. Pike biomass estimates have however decreased. This means there are more pike, but mean size of each pike is smaller.
The data used to produce figures 13 & 14 originate from records of fish over 99 mm FL. However, examination of the complete capture data for the 4 surveys shows a rapid rise in the number of juveniles for the 5 species since 2013. Figure 15 helps visualise this phenomenon. Figure 15 shows a decline in the number of fish over 99 mm FL over the survey period while the number recorded below 99 mm FL steadily increases over the same period. The two trend lines cross each other around 2017. This indicates that this site now contains more juveniles than adults. That said adult chub are still very evident at this site.
Figure 15 also shows the total estimate for number of fish present since 2017 has increased year on year. The estimate is even higher when the smaller species are included in the total (see table 5).

Evasion strategy: During the survey, chub utilised an unusual evasion tactic. On a number of occasions, operators saw adult chub bury themselves in soft silt. Some of the larger individuals deliberately pushed themselves deep into the silt to avoid the electric field and capture. This could suggest they use similar tactics when predators hunt them. It could also point toward a possible lack of suitable refugia for fish above a certain size in this section of the river.

Trout: Trout are sporadic captures at this site. They are considered in the 6 key species due to the chalk stream nature of the river. Trout are abundant in the upper reaches of the river. Their presence or otherwise in the central section of the river is noteworthy. Sea trout records exist from the lower sections of the river. Their lifecycle strongly suggests they would migrate to the upper reaches to find suitable spawning media and habitat. To date, trout recorded at this site do not identify as returning migratory sea trout.

Alders Spinney

Survey site characteristics

There are 2 mill structures downstream of Sparham pool before the river reaches Alders Spinney survey site.
Alders Spinney survey site contains varied and desirable habitat features within the 170 metre survey length. Features such as marginal riffles, pool, glide and sinusoidal bends are immediately evident, as are undercut banks, overhanging trees and abundant instream macrophytes. River width at this site is now stable at 9 metres. Bank morphology is largely unmodified dictated by river flow. Depth varies between 1 and 3 metres along the survey length and channel shape relies on hydraulic regime rather than anthropogenic influence.

The river connects well to the flood plain on the left hand bank at this site. The right hand bank is much higher than the left. Cattle graze the right hand floodplain during the summer months. Some marginal

poaching is evident and the banks are unfenced. Numerous fishing and water supply reservoirs lie behind the raised left hand bank.

Throughout the survey section, substrate contains mixed sand and silt. Cobble is visible in places along with scoured gravels. Introduced large riffle features span the river above and below the survey site. Established oak and hawthorn shade the water surface while willow branches touch the river surface and their roots grow below the surface. Extensive stands of Sparganium, Glyceria and Phragmites exist along the edge of the river.

Species	Total Number recorded	Number of fish over 99 mm FL
Stickleback	2	0
Lamprey	1	1
Bullhead	3	0
Chub	33	19
Common bream	1	1
Dace	79	49
Eels	1	1
Gudgeon	8	3
Minnow	274	0
Perch	3	3
Pike	10	10
Roach	36	35
Stone loach	5	0

Table 7: Species list and captures recorded in 2019 survey at Alders Spinney survey site. Total number and number of fish over 99 mm FL shown. Survey area 170 m x 9 m = 1530 m^2

Surveyed area at this site is the second smallest of all 6 sites Capture records show 13 species of fish caught in the 2019 survey; 456 fish in total (table 7). Historically barbel, trout and tench featured in the catch results at this site. Five indicator species are present (bullhead, eel, lamprey, stickleback and stone loach). Trout are missing from the 2019 captures. Trout are very scarce at this site, despite frequent observation of them on the upstream and downstream riffle features.

Minnow are abundant at this site, their numbers along with other fish below 99 mm FL will be an underestimate. Seventy-nine dace recorded in 2019 represent a healthy stock at this site; 49 of the dace caught are over 99 mm FL.

The percentage of fish over 99 mm FL does not fall below 49% for any of the 5 key species present. All the perch and pike recorded are above 99 mm FL along with 97% of the roach.

Long-term density at Alders Spinney survey site

Observations: long-term density (figure 16)

Roach

- Roach density estimate at this site in 2019 is 2.35 fish / 100 m^2. Twice the site long-term mean roach density estimate (1.24 fish / 100 m^2)
- Roach density estimate is highest in 2018 at 4.1 fish / 100 m^2
- Roach density estimates for fish over 99 mm FL are not available for 3 of the 17 surveys: namely 2009, 2015 & 2016. No roach records exist for 2009 or 2015 surveys.

Dace

- Density estimate for dace in 2019 (3.26 fish / 100 m^2) is the highest recorded of the 17 surveys. Site long-term mean density estimate is 1.14 fish / 100 m^2.
- Dace records exist from every survey although only 1 dace below 99 mm FL represents the species in 2008.
- The 3 highest density estimates noted in 2005, 2012 & 2019 could indicate a 7 year cycle
- Scale readings indicate a healthy mixture of year classes.

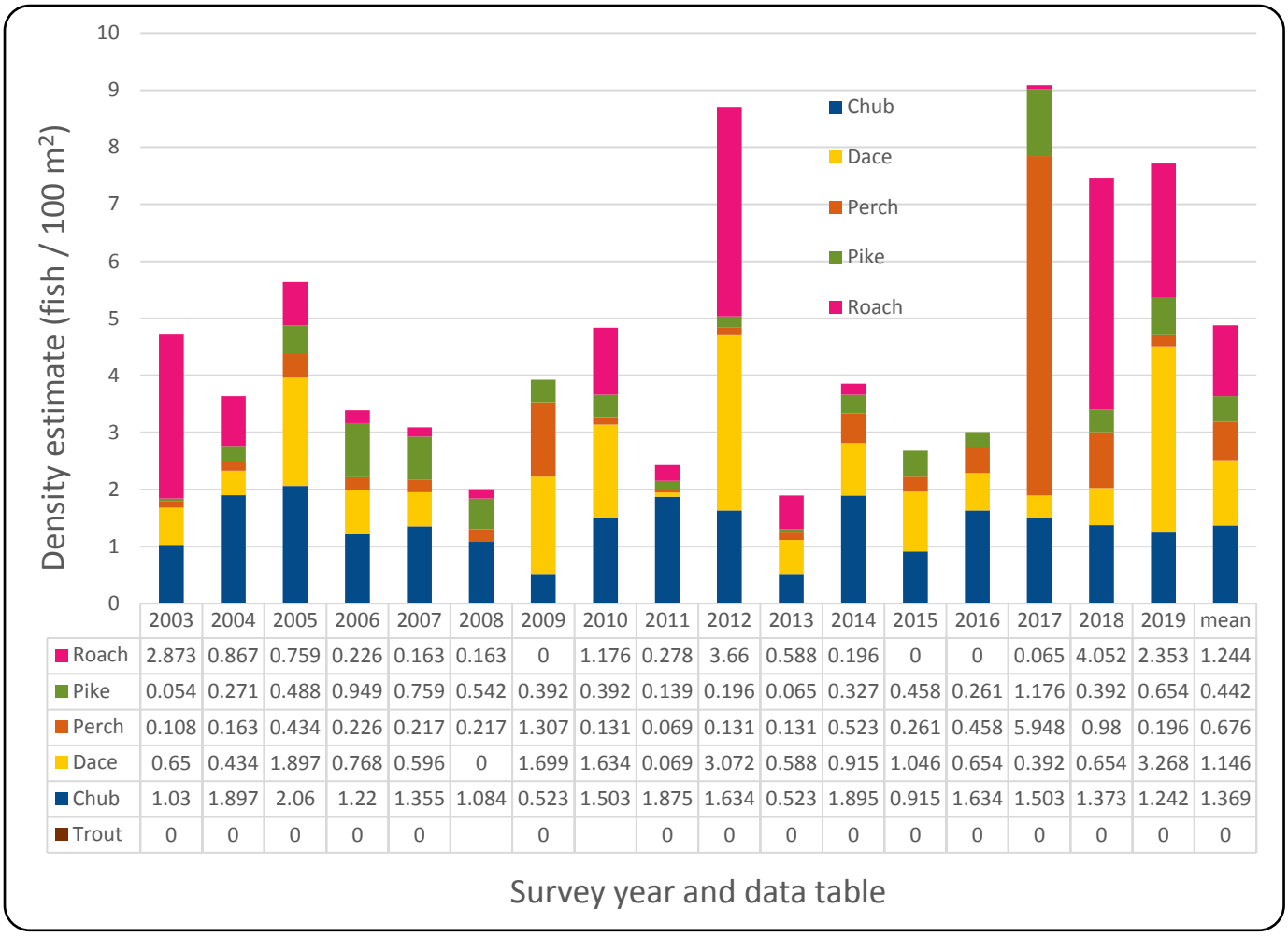
Chub

- Chub density estimate in 2019 (1.2 fish / 100 m^2) is lower that the site long-term mean estimate: 1.4 fish / 100 m^2
- Since 2016, chub density has declined by 22% to-date
- Chub over 99 mm FL are present in catch records for every survey, scale analysis shows a mixture of year classes are present at this site
- Highest density, in 2005 is 2.1 fish / 100 m^2.

Perch

- Perch density estimate; 0.2 fish / 100 m^2, recorded in 2019 is lower than the site long-term mean 0.7 fish / 100 m^2.
- Perch are represented in all surveys

- Perch density estimate reached its highest value in 2017: 5.9 individuals / 100 m^2: almost a magnitude higher than the site long-term mean
- Lowest perch density estimate occurred in 2011, dropping to 0.06 fish / 100 m^2.
- An indistinct 4 year cyclic pattern in perch density with 4 peaks in 2005, 2009, 2013 and 2017 seems to be evident



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	mean
Roach	2.873	0.867	0.759	0.226	0.163	0.163	0	1.176	0.278	3.66	0.588	0.196	0	0	0.065	4.052	2.353	1.244
Pike	0.054	0.271	0.488	0.949	0.759	0.542	0.392	0.392	0.139	0.196	0.065	0.327	0.458	0.261	1.176	0.392	0.654	0.442
Perch	0.108	0.163	0.434	0.226	0.217	0.217	1.307	0.131	0.069	0.131	0.131	0.523	0.261	0.458	5.948	0.98	0.196	0.676
Dace	0.65	0.434	1.897	0.768	0.596	0	1.699	1.634	0.069	3.072	0.588	0.915	1.046	0.654	0.392	0.654	3.268	1.146
Chub	1.03	1.897	2.06	1.22	1.355	1.084	0.523	1.503	1.875	1.634	0.523	1.895	0.915	1.634	1.503	1.373	1.242	1.369
Trout	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0	0

Figure 16 Long-term density estimates for 5 key species over 99 mm FL at Alders Spinney survey site.

Pike

- Pike are represented in all surveys
- The 2019 density estimate of 0.65 fish / 100 m^2 is higher than the long term site mean: 0.44 fish / 100 m^2
- Highest pike density estimate occurs in 2017:1.17 fish / 100 m^2. The same year as highest perch density occurs (see findings above).
- Lowest pike density estimate occurs in 2003 (0.05 fish / 100 m^2)

Long-term biomass at Alders Spinney survey site

Observations: long-term Biomass estimates (figure 17)

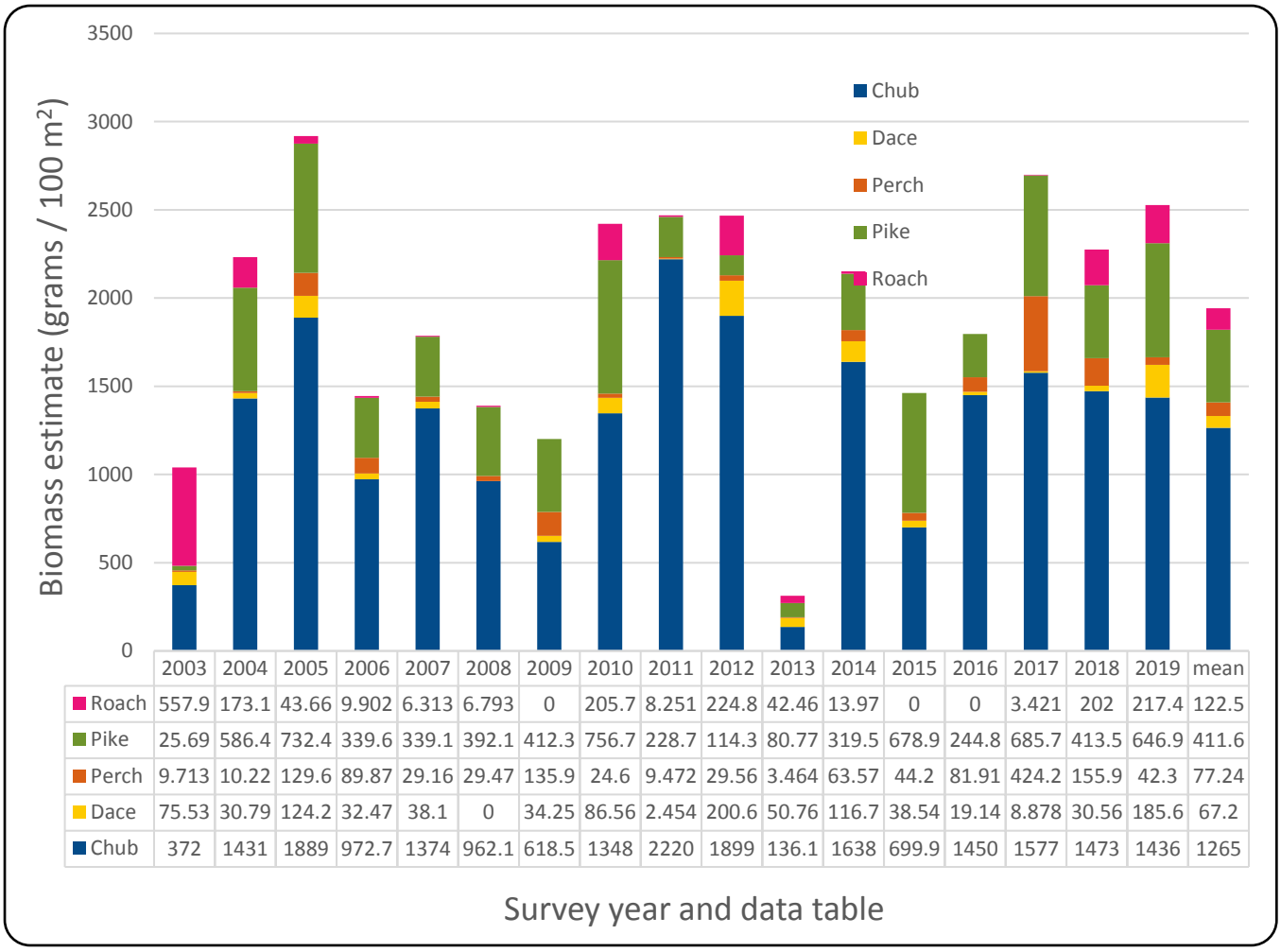
Roach

- Roach biomass estimate in 2019 is 217 grams / 100 m^2 almost twice that of the site long-term mean 122 grams / 100 m^2.
- In 2003 roach biomass estimate peaked at 557 grams / 100 m^2
- The lowest biomass estimate, not counting the years when roach over 99 mm FL were absent, occurred in 2017: 3 grams / 100 m^2.

Dace

- Estimated dace biomass in 2019: 185 grams / 100 m^2: is more than 2.5 times the site long-term mean estimate: 67 grams/100 m^2.

- The highest dace biomass estimate occurred in 2012: 200 grams / 100 m^2.
- Excluding 2008, as no dace over 99 mm FL are recorded the lowest biomass estimate occurred in 2011 with an estimate value of 2.4 grams / 100 m^2.
- Peaks in dace biomass estimates follow those of density: 2005, 2012, 2019.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	mean
Roach	557.9	173.1	43.66	9.902	6.313	6.793	0	205.7	8.251	224.8	42.46	13.97	0	0	3.421	202	217.4	122.5
Pike	25.69	586.4	732.4	339.6	339.1	392.1	412.3	756.7	228.7	114.3	80.77	319.5	678.9	244.8	685.7	413.5	646.9	411.6
Perch	9.713	10.22	129.6	89.87	29.16	29.47	135.9	24.6	9.472	29.56	3.464	63.57	44.2	81.91	424.2	155.9	42.3	77.24
Dace	75.53	30.79	124.2	32.47	38.1	0	34.25	86.56	2.454	200.6	50.76	116.7	38.54	19.14	8.878	30.56	185.6	67.2
Chub	372	1431	1889	972.7	1374	962.1	618.5	1348	2220	1899	136.1	1638	699.9	1450	1577	1473	1436	1265

Figure 17 Long-term biomass estimates for 5 key species over 99 mm FL at Alders Spinney survey site.

Chub

- Estimated chub biomass in 2019 at this site is 1435 grams / 100 m^2. The long-term site mean is 1264 grams / 100 m^2.
- The peak biomass estimate: 2220 grams / 100 m^2 occurred in 2011: lowest biomass estimate is recorded in 2013: 136 grams / 100 m^2
- Chub biomass estimates appear to show a 6 year cycle between peaks (see figure 17: 2005, 2011, & 2017)
- With exception of 2003, chub biomass exceeds all other species in every survey.
- Chub biomass estimate has declined for the last 3 years (2017 ~ 2019).

Perch

- Perch biomass estimate for 2019 is 42 grams / 100 m^2. A value lower than the site long-term mean of 77 grams / 100 m^2
- Perch biomass estimate at this site peaked in 2017 the same year as peak density estimate: 424 grams / 100 m^2
- Since 2017, perch biomass estimate has reduced by a factor of ten.

Pike

- Pike biomass in 2019 is 645 grams / 100 m^2; higher than the site long term mean estimate: 411 grams / 100 m^2
- The 2019 biomass estimate is in the top quartile of all 17 surveys.
- Peak biomass estimate occurs in 2010: 756 grams /100 m^2.
- Lowest biomass estimate occurs in 2003: 25 grams / 100 m^2

Comments / Interpretation

Records for 16 separate species of fish exist from the 17 surveys at this site. The 2019 survey includes 13 of those species. Barbel, tench and trout are not present in the 2019 capture list. Barbel last featured in survey results in 2010: tench in 2016 & 2017.

In 2019, the longest (largest) individual chub and dace, along with the second largest roach and pike recorded across all sites were captured from Alders Spinney. The variety of abundant habitat available at this site along with good water quality and quantity should ensure that this site remains one of the top performing sites on the River Wensum.

No reason is apparent for the drastic reduction in the combined biomass estimate of the key species in 2013. Total density at the site in 2013 is below 2 fish / 100 m^2, but this applies in 2008 as well. Yet in 2008, biomass estimate (1390 grams / 100 m^2) although low compared to other years is well above the biomass recorded in 2013 (313 grams / 100m^2).

High pike biomass estimates noted in 2005, 2010, 2015, 2017, 2018 & 2019; show little or no relation to biomass estimates of any one species of prey (see figures 16 &17). However, further scrutiny of figures 16 & 17, indicates a weak association between pike biomass and total density estimate (i.e. highest pike biomass estimates occur in those years where total density estimate is around or above 5 fish / 100m^2).

Highest estimates for perch biomass and density occur in 2017. Density estimate jumps by a factor of 13 between the 2016 and 2017 surveys. Perch biomass estimate shows a 5.5 fold increase over the same period. Raw data show 77 perch measured in the 2017 survey; of that total, 58 (75%) are 160 mm FL or less. Using age length metrics 75% of the total captured are less than 1+ years of age.
The 2016 survey took place in September. Perch fry from a late July spawning event in 2016 would be too small in September for electric fishing to affect them effectively; they would go unrecorded.
At the time of the 2017 survey however, perch that survived from 2016 would be over 99 mm FL and effectively sampled. The sudden spike in both density and biomass for perch in 2017 is likely a direct result of a late July spawning event in 2016.

Hellesdon Road, (Alberts)

Survey site characteristics

This annual site, accessed from Hellesdon road in the suburbs of Norwich is the furthest downstream site surveyed. The site is effectively isolated between Hellesdon mill; approximately ¾ of a kilometre upstream and New Mills some 3.6 kilometres downstream. Heavy modification of the bank and channel course using piling and straightened sections is evident along the 4.5 kilometres section of river between the mills. Survey area has changed over time despite the constrained width of the river. River width is currently 13.5 metres. Survey length since 2009 is stable at 150 metres. On average, water depth is 2.5 metres and remains almost constant across the width of the river.

Species	Total Number recorded	Number of fish over 99 mm FL
Trout	1	1
Bullhead	2	0
Chub	25	15
Dace	20	15
Eel	2	2
Gudgeon	2	1
Minnow	15	0
Perch	3	3
Pike	5	5
Roach	75	64
Stone loach	1	0

Table 8: Species list and captures recorded in 2019 survey at Hellesdon Road, Alberts survey site. Total number and number of fish over 99 mm FL shown. Survey area 150 m x 13.5 m = 2295 m^2

Available habitat is limited although established bankside trees (Alder, Oak & Willow) and rushes do provide shade and refugia. The majority of the survey length is glide orientated with marginal eddies apparent where tree roots protrude through the wooden piling and into the river. Larger eddies exist created by the slight bankside variations and a sweeping bend near the upstream limit of the site. Assorted sediments form the bed substrate. Silt and sand predominate, but where flow is sufficient to scour the bed, mixed gravels and cobbles are present. Instream macrophyte growth in this section tends to be dense and well anchored. Overhanging riparian

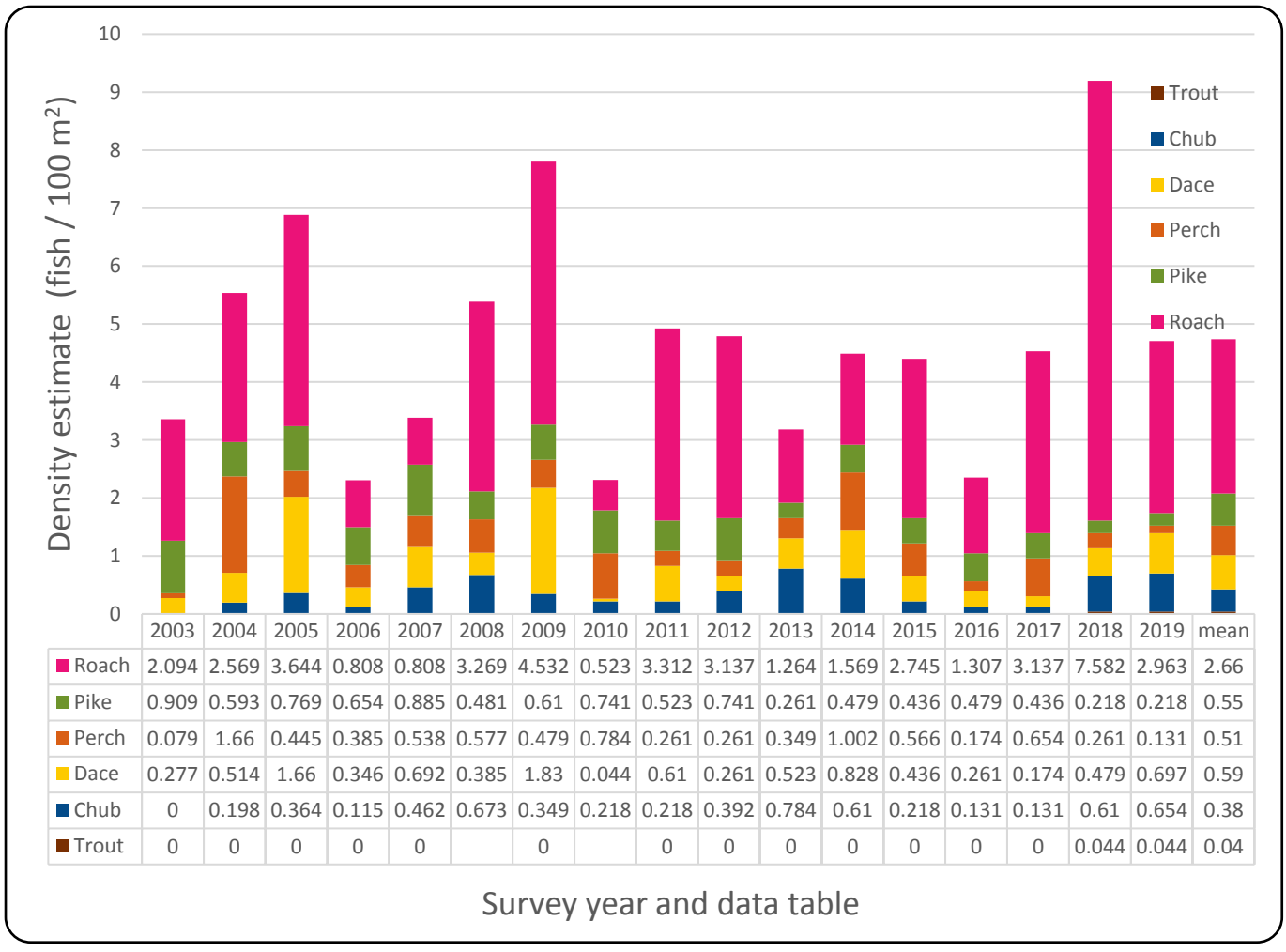
plants are abundant and a long list of marginal plants are visible.

Of the total number of 151 fish recorded, 106 are over 99 mm FL. 11 species are present in 2019 at this site. Captures from previous surveys record 18 different species of fish at this site. Roach predominate, currently and historically, in 2019 a total of 75 are recorded; of which 64 are over 99 mm FL. Four, indicator species are present: bullhead, eel, trout & stone loach.
A fifth and sixth indicator species are present, both observed during the survey however, the two species: lamprey and stickleback, evaded capture.

Fifteen minnow represent their population at this site however this is a gross underestimate. Many more individuals are present but evaded capture through size selective bias or because the stunned fish were not accessible for netting. The number of bottom dwelling species such as bullhead, eel, gudgeon, and stone loach shown in table 8 indicate their presence but are an underestimate too.

Long-term density at Hellesdon road, Alberts survey site

Observations: long-term density (figure 18)



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	mean
Roach	2.094	2.569	3.644	0.808	0.808	3.269	4.532	0.523	3.312	3.137	1.264	1.569	2.745	1.307	3.137	7.582	2.963	2.66
Pike	0.909	0.593	0.769	0.654	0.885	0.481	0.61	0.741	0.523	0.741	0.261	0.479	0.436	0.479	0.436	0.218	0.218	0.55
Perch	0.079	1.66	0.445	0.385	0.538	0.577	0.479	0.784	0.261	0.261	0.349	1.002	0.566	0.174	0.654	0.261	0.131	0.51
Dace	0.277	0.514	1.66	0.346	0.692	0.385	1.83	0.044	0.61	0.261	0.523	0.828	0.436	0.261	0.174	0.479	0.697	0.59
Chub	0	0.198	0.364	0.115	0.462	0.673	0.349	0.218	0.218	0.392	0.784	0.61	0.218	0.131	0.131	0.61	0.654	0.38
Trout	0	0	0	0	0		0		0	0	0	0	0	0	0	0.044	0.044	0.04

Figure 18 Long-term density estimates for 6 key species over 99 mm FL at Hellesdon Road, Alberts survey site.

Roach

- Roach density estimate in 2019 is 2.96 fish / 100 m^2; higher than the site long-term mean estimate: 2.7 fish / 100 m^2
- Roach density estimate is highest in 2018 at 7.6 individual / 100 m^2
- Lowest density estimate: 0.5 fish / 100 m^2 in 2010 is 15 times lower than that of 2018
- Roach feature in all 17 surveys at this site

Dace

- Density estimate for dace in 2019 (0.7 fish / 100 m^2) is higher than the site long-term mean estimate (0.6 fish / 100 m^2) and is the highest since 2015
- Highest dace density estimate in 2009 is 1.8 fish / 100 m^2. Lowest density estimate occurs in 2010: 0,04 fish / 100 m^2.

- Dace over 99 mm FL are present each year at this site. Scale readings indicate a mixture of year classes

Chub

- Chub density estimate in 2019 (0.65 fish / 100 m^2) is higher than the site long-term mean estimate: 0.4 fish / 100 m^2.
- The 2019 density estimate is the highest since 2013 indicating an increase since that time
- Scale analysis shows a mixture of year classes are present at this site
- Highest density, in 2013; is 0.8 fish / 100 m^2. Lowest density occurs in 2006: 0.11 fish / 100 m^2

Perch

- Perch density estimate; 0.1 fish / 100 m^2, recorded in 2019 is considerably lower than the site long-term mean 0.5 fish / 100 m^2.
- Perch over 99 mm FL are represented in all surveys
- In 2004 perch density estimate is at its highest value: 1.7 fish / 100 m^2: over three times the long-term site mean
- Lowest perch density estimate occurred in 2003 when the density estimate was 0.08 fish / 100 m^2.

Pike

- Pike are represented in all 17 surveys
- The 2019 density estimate of 0.2 fish / 100 m^2 is higher than the long term site mean: 0.55 fish / 100 m^2
- Highest pike density estimate occurs in 2003: 0.9 fish / 100 m^2.
- Lowest pike density occurs in 2018 & 2019 (0.2 fish / 100 m^2)
- Overall pike density has decreased since 2003

Trout

- Trout are represented in the 2018 & 2019 surveys
- The 2019 density estimate: 0.04 fish / 100 m^2 equals the site long-term mean
- In total 2 trout over 99 mm FL are recorded at this site from the 2018 and 2019 surveys

Long-term biomass at Hellesdon road, Alberts survey site

Observations: long-term Biomass estimates **(figure 19)**

Roach

- Roach biomass estimate in 2019 is 351 grams / 100 m^2; 70 grams /100 m^2 higher than the site long-term
- Biomass estimate is highest in 2009 at 747 grams / 100 m^2
- Peaks in biomass estimate of more than twice the “normal” biomass estimates occur in 2009 and 2018

Dace

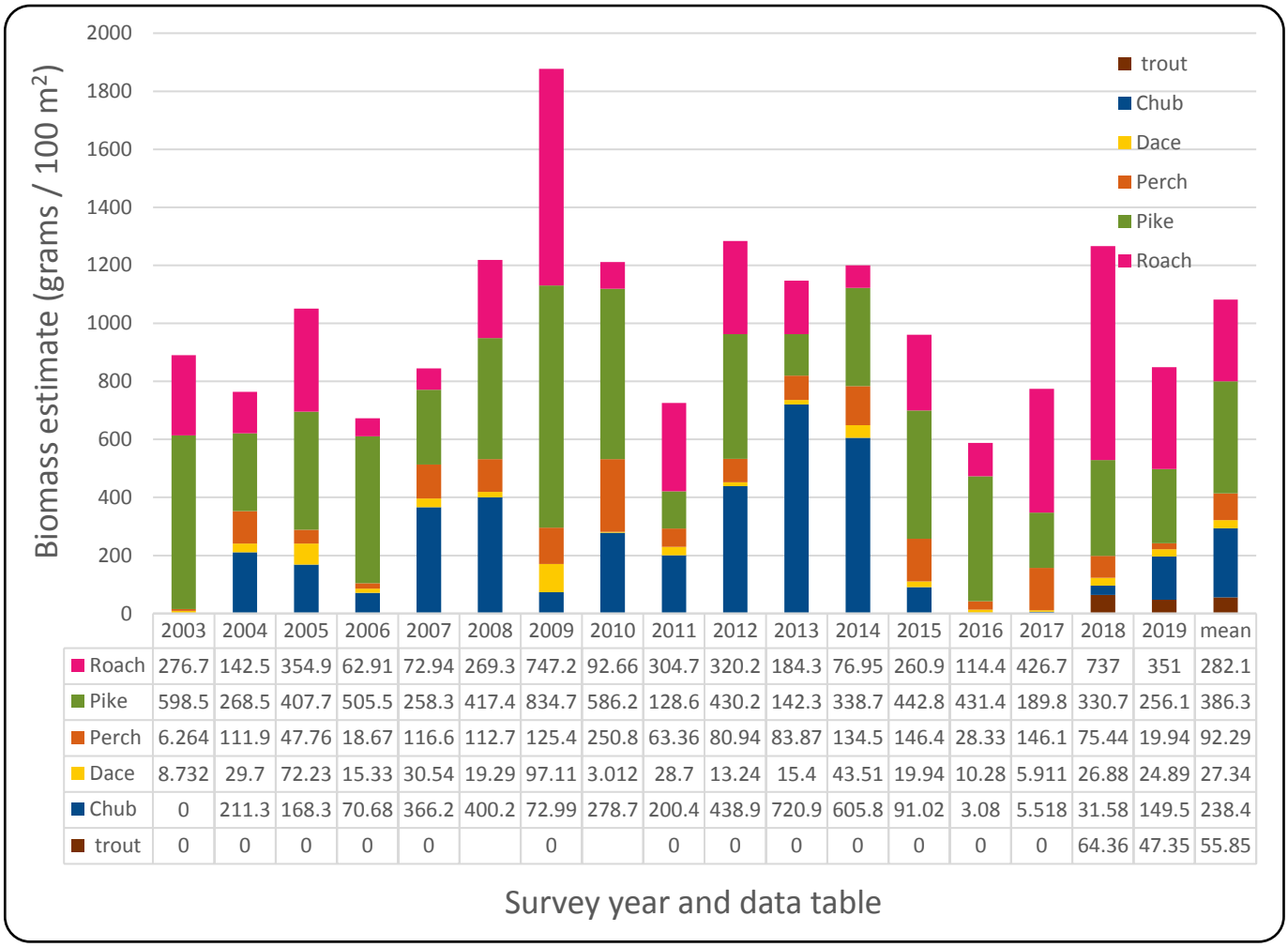
- Estimated dace biomass in 2019 is 25 grams / 100 m^2: lower than the site long-term site mean estimate of 27 grams / 100 m^2
- The highest biomass recorded occurred in 2009: 97 grams / 100 m^2 is 3.5 times higher than the long-term mean estimate.
- Despite the significant peak in 2009, dace biomass has declined overall since 2003.

Chub

- Estimated chub biomass in 2019 at this site is 149 grams / 100 m^2. The long-term site mean is 239 grams / 100 m^2.
- The peak biomass estimate: 721 grams / 100 m^2 occurred in 2013: lowest biomass estimate barring 2003 (zero) is recorded in 2016: 3 grams / 100 m^2
- Chub biomass fluctuates widely at this site, the 2019 estimate is the highest since 2016

Perch

- Perch biomass estimate for 2019 is 20 grams / 100 m^2 almost 4 times lower than the site long-term mean of 92 grams / 100 m^2
- Perch biomass estimate at this site peaked in 2010: 251 grams / 100 m^2
- Over the survey period (2003 ~ 2019), perch biomass has gradually increased. The 2019 estimate is however, the fourth lowest value recorded. Lowest value recorded in 2003: 6.2 grams / 100 m^2.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	mean
Roach	276.7	142.5	354.9	62.91	72.94	269.3	747.2	92.66	304.7	320.2	184.3	76.95	260.9	114.4	426.7	737	351	282.1
Pike	598.5	268.5	407.7	505.5	258.3	417.4	834.7	586.2	128.6	430.2	142.3	338.7	442.8	431.4	189.8	330.7	256.1	386.3
Perch	6.264	111.9	47.76	18.67	116.6	112.7	125.4	250.8	63.36	80.94	83.87	134.5	146.4	28.33	146.1	75.44	19.94	92.29
Dace	8.732	29.7	72.23	15.33	30.54	19.29	97.11	3.012	28.7	13.24	15.4	43.51	19.94	10.28	5.911	26.88	24.89	27.34
Chub	0	211.3	168.3	70.68	366.2	400.2	72.99	278.7	200.4	438.9	720.9	605.8	91.02	3.08	5.518	31.58	149.5	238.4
trout	0	0	0	0	0		0		0	0	0	0	0	0	0	64.36	47.35	55.85

Figure 19 Long-term biomass estimates for 5 key species over 99 mm FL at Hellesdon Road, Alberts survey site.

Pike

- Pike biomass in 2019 is 256 grams / 100 m^2. The site long-term mean is 386 grams / 100 m^2
- The 2011 biomass estimate is the lowest of all the surveys: 129 grams / 100 m^2.
- Peak biomass estimate occurs in 2009: 834 grams /100 m^2.
- Pike biomass estimates follow trends in roach biomass estimate

Trout

- Trout biomass estimate in 2019 is 47 grams / 100 m^2. The site long-term mean is 56 grams / 100 m^2
- Trout biomass is highest in 2018 the only other survey at this site recording trout: 64 grams / 100 m^2
- Both the 2018 and 2019 biomass estimates derive from single fish captures.

Comments / Interpretation

Records for 11 separate species of fish exist for the 2019 survey. Historic records indicate 18 separate fish species captured in surveys between 2003 and 2019. Barbel, bream, lamprey, rudd, ruffe, stickleback and tench are absent from the 2019 species list. Barbel were last captured in 2012. Lamprey were present at the site in 2019, seen at the time of survey but evading capture. Bream were recorded in 2018 whilst rudd were caught 10 years prior in 2008. Ruffe were last recorded in 2007. Stickleback and tench captures indicate their presence within the last 3 years.

Roach density estimates reported for this site are the highest of the 6 key species considered for all years and from the 5 sites: they thrive at this site (figure 18). The deep, sedate flow of good quality water suits them. The largest roach captured across all sites are here. Six of the 75 individuals caught in 2019 (table 9) measure over 250 mm FL; the largest (310 mm FL) equates to 0.6 Kg (1lb 6 ozs) using weight length metrics (see table 1). The largest roach specimens display archetypal colouration and form (see image on front-page of report). With such high numbers of roach present, that attain a good size, roach biomass estimates are correspondingly high; in most years, roach biomass exceeds that of pike or chub (figure 19).

Juvenile roach (under 99 mm FL) are caught each year at this site, indicating spawning success and year on year recruitment to the population. Scale analysis indicates roach from each year class from 1+ to 10+ are often present. In addition, juvenile roach and fry are likely to be washed downstream by high flows before settling at this site.

The mix of dace, their size and age at this site indicate spawning and recruitment to the population year on year. Additionally their capture in each survey indicates that ample quantities of good quality water are available to them. Their continuous residence at this site also indicates suitable habitat is available for them. Dace rarely exceed 1lb in weight (0.5 kg) individuals above 10 ozs (0.7Kg) are considered specimen sized. The majority of dace recorded at this site measure between 100 ~ 200 mm FL (1 ~ 4 ozs: 30 ~120 grams). The high biomass estimates recorded in 2005 and 2009 are all the more remarkable when considering their average weight.

Chub captures exist for 16 of the 17 surveys at this site. Density estimates over the 16 surveys seem to display a variable 5 to 6 year cycle with peaks indicated in 2007 ~ 2008; 2013 ~ 2014 & 2018 ~ 2019 (see figure 18). Biomass estimates mimic density estimates i.e. peaks in 2007~ 2008; 2013~ 2014 and 2018 ~ 2019 (figure 19). However the 2018 ~ 2019 biomass estimates are significantly below those recorded in 2007~8 and 2013 ~14. This indicates that despite density estimates being on a par with previous peaks, the mean size of chub in 2018 ~ 2019 has decreased compared to previous biomass estimates (see figures 18 & 19).
Analysing the raw data from the years 2007 ~ 8 and 2013~14 it is apparent that very few of the chub caught are less than 200 mm FL. In contrast, the majority of the chub captured in 2018 ~ 19 surveys are between 99 and 200 mm FL. Few are over 200 mm FL
A possible explanation may relate to the prolonged dry weather periods recorded in 2018 and 2019. The associated lower flows and decreased dissolved oxygen that prolonged dry weather could cause may have influenced this sites selection by larger chub. Angling captures upstream of the site, where higher oxygen concentrations exist due to the increased influence of the millstream, indicate that the expected bigger specimens are still present.

The lower numbers of perch at this site are growing well. This statement centres on the decline in perch density estimate since 2003 yet biomass estimate shows a gradual increase for the same period. Juvenile recruitment is sporadic as is spawning success at the site.

Pike density and biomass estimates have declined since 2003; the 2019 estimates for both are among the lowest estimates recorded at this site. The abundant roach stock suggests that predatory species should benefit however, there is no apparent relationship between pike and roach density or biomass at this site.

The capture of trout at this site in 2019 is exciting. The habitat and flow regime at this site are not ideally suited for trout. This particular individual is a transient migrant, in fact a sea trout. Identified as such by scale analysis. Scale readings indicate this fish has spent 2 years in freshwater growing before migrating downstream to sea and returning to spawn, twice. The timing of this capture strongly suggests this fish is migrating upstream for a third time, to spawn.
One other record exists for trout at this site; a larger fish caught in 2018. Identified as a “slob” trout ie one that migrated downstream to the estuary but did not go to sea, this trout was caught from almost the same spot within the survey site as the sea trout caught in 2019.
These two captures endorse angling evidence that sea trout exist in the Wensum catchment and that provision for their specific water quality, habitat and water temperature requirements need to be in place to ensure they continue to migrate up and down the river.

Health of the fish population and discussion

Biomass: When assessed over the long-term biomass estimates show slight increases for each key species bar one: pike. Pike biomass over the long term is however stable. All species show yearly fluctuations in biomass estimates from year to year (figure 5). Regression analysis supports the slight increase in biomass estimates but indicates the assessment is not very robust due to the yearly fluctuations mentioned.

Standing crop (biomass): a rivers' ability to support populations of fish is often monitored using standing crop (biomass). A number of factors combine to determine ultimate biomass of a river. It is not the intent of this report to dwell on determining ultimate biomass capacity for the River Wensum but figure 5 lends itself to some rudimentary observations.

It is obvious from figure 5 that pike and chub biomass are prime factors in the total biomass of a site. Pike and large chub are predators, relying heavily on an abundance of prey to enable their continued growth and lifestyle. Sites where large chub and pike exist exhibit high biomass estimates: sites such as D/S Gt Ryburgh, Alders Spinney, Elsing Mill and most recently Sparham Pool (figures 7, 17, 24 & 14 respectively). It is also obvious that protecting and enhancing the lower levels of the food chain will increase biomass at a site both directly and indirectly.

Discussion: Fish density estimates for the River Wensum are low compared to rivers outside of Norfolk (contact us if you would like to see reports of other rivers in East Anglia). There could be multiple reasons for this but the high proportion of chalk derived base flow to the river is foremost among them.
Chalk derived base flow maintains a steady flow of cool water in the river and ensures raised alkalinity in the river (typically pH8). The cooling effect of the groundwater and the high alkalinity are ideally suited to game and indicator species (trout, bullhead, stone loach, lamprey). However, the low temperature and high pH limit productivity in the river, consequently primary and secondary food webs are restricted when compared to rivers in other areas of the country.
Nutrient input to the river affects productivity. Historically, treated sewage discharged to the river from water treatment plants contained high levels of phosphate that increased primary productivity of the river. Enforcement of legislation to remove phosphate prior to discharge has led to consequent improvements to water quality and clarity by reducing the frequency and severity of algal blooms in the river. In many years, they no longer occur. These limiting factors affect coarse fish stocks, their growth, recruitment and biomass in the river.

Another factor that may be affecting fish stocks is competition and predation from invasive signal crayfish. No monitoring data are available for crayfish numbers in the River Wensum but observations at the time of survey suggest an increasing population since their escape from a crayfish farm in the 1980's. Crayfish are insatiable; they eat, among other items; fish eggs, juvenile fish, macrophytes and their own young. As the population increases, so too their impact. Unfortunately it is extremely difficult to control crayfish numbers and impossible to eliminate them. Other rivers e.g. the River Wid in Essex also have high numbers of signal crayfish; nonetheless the Wid supports good fish populations.

Chub: The current stock of chub in the river are natural spawned fish that have recruited to the population over many years. Some of the more mature specimens are 16+ years old.
Introduced in the mid 1970's chub do not just survive in the river but thrive, especially in the sections they find most suitable e.g. Swanton Morley, D/S Elsing Mill, Alders Spinney, to name a few. The capture records from sites upstream of the initial stocking location suggests barriers have not restricted their expansion throughout the central section of the river. However, this may not be the case as there is strong anecdotal evidence that chub, captured from the initial release site were released after transport to different sections of the river.

Angling reports indicate that specimen chub of 6.5lbs (3Kg) and over, while not common, do exist in the river and individuals over 8lbs (3.6Kg) are reported in the angling media. Few individuals of this size feature in the survey results, the majority of chub captured weigh between 1 and 5 lbs. Chub, despite their often mediocre density estimates, comprise a high proportion of overall biomass at most sites due to their

large size compared to other species. Paradoxically, the presence of high numbers of crayfish may benefit large chub, as they are known to prey on them.

Dace: Dace density and biomass estimates in 2013 (Figure 4 & 5) are the highest estimates for the species from the 17 surveys. This is mainly the result of an exceptional capture of dace at D/S Gt Ryburgh Bridge site. A peak of similar magnitude occurs in 2005; which is not attributable to an individual site. These observations suggests that the peak in 2013 is due to localised successful spawning and recruitment while the earlier peak (2005) is due to successful spawning and recruitment throughout the river. The latest survey results look positive for dace with numbers and biomass above the long-term mean, continuing the upward trend since a low in 2017.

Pike: Numbers of pike captured (density) belies their biomass. Pike density is often low: in contrast, pike biomass tends to dominate the capture charts at site and reach level.
That said, it is interesting to note the reversal in pike and trout density in the D/S Gt Ryburgh Bridge results (figure 6) and the effects on pike biomass (figure 7). In the years after 2013, pike density rarely exceeds that of trout. Pike biomass however always exceeds the biomass of trout and all other species except in 2013 when dace biomass is highest. This means after 2013, there are fewer pike, which are living longer and subsequently getting bigger.
Scrutiny of figures 4 and 5 indicate that peaks in pike density do not always correspond to peaks in pike biomass. Supported by the previous observation, this suggests that pike biomass at a site relates more to longevity than fecundity, i.e. the longer a single pike lives the greater its biomass rather than greater number of short lived small pike. Of course, this also relies on capture of pike at the time of survey.
The 2019 survey shows a continuation of a stable, healthy pike population.

Roach: roach density and biomass show increases over the long term (figure 4 and 5) although both estimates can fluctuate wildly. At 4 of the 6 survey sites roach density is often the highest of all species present (figures 8, 11, 16 & 18). In 2019, roach weighing over 10 ounces (280 grams) were caught from 4 of the 6 sites surveyed (table 1): a trio of roach weighing over 1lb 4 ounces (570 grams) were recorded from the furthest downstream survey site.
Large roach are not abundant in the river however; roach over 10 years of age are recorded each year. Growth rate for roach in the River Wensum is slow when compared to growth rates of roach in other rivers. Some roach measuring less than 99 mm FL are aged 3+. The reasons are probably those outlined above i.e. cool water and low nutrients.
Juvenile roach (fish less than 99 mm FL) are present at all sites surveyed in 2019 (tables 3, 4, 5, 6, 7 & 8) indicative of successful spawning and recruitment for the years prior to survey. As mentioned previously fish recorded under 99 mm FL are underestimates.
Analysing the historic data for roach indicates no significant correlation between the number or density of adults and juveniles at a site or reach level. This could be due to limitations of the survey method, however in some cases at site level peaks in adults captured compare to peaks in juveniles recorded albeit offset by a year or 2. However, the density of adults caught compared to juveniles recorded at the Hellesdon Road Alberts site suggest that a high proportion of adults residing there are as a consequence of fish being washed downstream in high flow events. This is supported by the low number of juveniles recorded at the site compared to the high number of adults.

Bream: Historically there are few bream recorded in the central section of the River Wensum. On surveys that include bream, seldom more than 2 or 3 relatively juvenile individuals indicate their presence. This observation is not in keeping with angling evidence.
Anglers catch bream in the River Wensum as recorded in angling media; individual specimen sized bream are present, weighing 8lbs (3.7 Kg) or more. Locating the semi-nomadic bream shoals in the river, once found, results indicate repeat captures of individuals from a shoal extending over many years.
The reason these larger bream rarely feature in survey results is due in part to survey sites being located away from their restricted and discrete populations.
In terms of biomass, there is no doubt that the number of bream in the river would influence biomass results at site and reach level. It is unlikely bream biomass would challenge pike or chub dominance, it may however surpass biomass estimates of roach and dace and increase overall biomass.

Water Framework Directive (WFD)

A number of elements determine WFD classification for the central section of the River Wensum, identified by waterbody number GB105034055881.

Overall classification is Moderate (2019 rating)

Some of the elements used for classification are shown below:

Biological element:

- fish classification is High (2016 classification: Good)
- Invertebrate classification is High (no change from 2016; High).
- Macrophytes and phytobenthos combined classification is Moderate (no change from 2016)

Physico-Chemical element:

- Classification is Good (same as 2016 classification)

Specific pollutant element:

- Classification in 2016 and 2019 is High.

Hydro-morphological supporting elements:

- **Hydrological regime:**
- Does Not Support Good for both 2016 and 2019 classifications but the class is uncertain. However, in 2013 the classification was the same but certain. This means that there is more confidence in the 2013 classification being correct whereas the 2016 and 2019 classification could be better due to changes in hydrological regime in the interim period.

Discussion

It is clear that many elements of the Wensum waterbody are assessed as being healthy, with a good or high WFD classification, including fish. The overall WFD classification is based on the lowest classification of the biological elements; in this case the moderate class for macrophyte and phytobenthos. The macrophytes and phytobenthos element is a combined assessment of plants in the river and algae growing on surfaces such as stones and submerged plant leaves. Within this assessment, plants are classed as good and algae (phytobenthos) as moderate. Many rivers in East Anglia have moderate or worse status for phytobenthos. These algae are primarily affected by siltation and high nutrients in the river, this may improve if efforts to control diffuse pollution continue along with improved sediment transport. However, it is believed the high alkalinity in the River Wensum interferes with the accuracy of the assessment method and so the classification may not reflect a true problem.

The other failing element is hydrological regime, meaning the amount of water in the river compared to the assessed Ecological Flow Indicator. The abstraction pressure on the river has been assessed as causing a failure, at band 1 – the lowest of 3 bands of impact. The Environment Agency is working to rectify this situation through its Abstraction Licencing Strategy, regulation of abstractors and working with water companies. It is worth noting that the majority of abstraction is at the bottom end of this stretch of river – the AWS abstraction point is below Hellesdon Road, Alberts survey site. Impacts to fish ecology upstream of the abstraction point will occur but should not be detrimental and relatively low.

Planned and recent actions

For centuries, the River Wensum has been modified to enable milling and land drainage. The result is a river that is often unnaturally wide and contained in overdeep channels. The mills create a series of impoundments. The Wensum Restoration Strategy, delivered by the Environment Agency working alongside Natural England aims to reverse and mitigate some of these changes. Other bodies including

angling clubs have carried out their own projects (Costessey point, Lyng, Swanton Morley). These have used techniques such as flow deflectors, addition of gravel, reconnecting bypassed meanders, fry bays and off-stream refuge areas to create additional natural hydromorphology and habitats. Below are some recent and future examples of projects carried out under the restoration strategy.

In October 2019, improvements over a 1.3 km stretch of the river from the A1067 road-bridge (Lenwade) downstream to a wooden footbridge opposite great Witchingham Hall took place. This section includes a part of the river fishable from the Bridge Inn fishery.
The restoration features here included:

- the hinging of willow trees to provide multiple habitat benefits such as flow variation, deflection, flood refuge, shade and shelter
- installation of woody material features to provide in-channel habitat and flow deflection,
- stabilising eroding bank edges by re-profiling the vertical edges to reduce sediment ingress
- Working the uniform gravel bed into a more diverse riffle and pool habitat, to increase flow heterogeneity.

Completed in summer 2020, an eel pass and fish ladder installed at Hellesdon Mill provide access to 5 Km of river above the mill upstream to Costessey Mill. Previously an elver trap at the site helped eel passage and recovery with captured elvers, counted before release above the mill. Downstream, New Mill also has an eel trap.
As a point of interest, in 2017, three eel less than 170 mm FL were recorded from a survey site on the river Tud. The river Tud joins the River Wensum downstream of Hellesdon Mill. Based on their size (age), for these individuals to be captured at a survey site on the river Tud they would have been counted and released after using the eel trap to ascend New Mills.

The Hellesdon fish survey site is 750 metres downstream of Hellesdon mill and 4 Km above New Mill; the tidal limit of the river Wensum. New Mill is a significant barrier to migration for fish of all species.
In early 2020 the gates at New Mill were fully lowered over the course of 3 days to assess the effects on the river upstream. River levels dropped immediately upstream and for a distance of 1.5 Km before the raised gravel bed below Mile Cross Road Bridge served to throttle and maintain the river level upstream of it. Further exercises are planned with a view to remove or modify the gates at New Mills to allow fish passage and future flood mitigation.

A proposed restoration scheme in 2020 at Attlebridge is rescheduled to commence in June 2021. Here, a further 1.3km stretch of river between Marriott's Way downstream to the A1067 Fakenham Road bridge will have features installed such as:

- woody material,
- fry bays,
- reinstating eroding bank
- Tree planting to shade areas of exposed channel.

Recommendations

Considering historic and more recent survey results there is a need to support and where possible enhance recruitment to the River Wensum fish population.

There are existing measures in some sections of river to support recruitment to all species e.g. off river flood refuge (Gt Ryburgh, Swanton Morley, Costessesy meadow). Increased spawning substrate in the form of coarse and fine gravel riffles (Gt Ryburgh, Lyng, Swanton Morley, Lenwade) to support those species dependent on such. Woody material flow deflectors to create silt berms that provide habitat for juvenile lamprey (and predator evasion; see Sparham pool section). Reconnection of original sinuous sections of river (Gt Ryburgh) and creation of same (Lenwade, Attlebridge).
All are beneficial and the previous sections show how their inclusion benefits the fish assemblies at sites along the river. It should be noted that some of the features mentioned require periodic maintenance to remain effective.

Other beneficial actions are:

- Improving fish passage at mills and other structures (See previous section; re. Hellesdon Mill)

- Habitat improvements that address historic widening, deepening and straightening, eg flow deflectors, addition of gravel
- Tree planting to provide shade to keep water temperatures down in the face of global warming
- Fencing livestock away from the river bank, with drinking water available through limited river access or cattle troughs (At many of the survey sites evidence of cattle poaching is apparent with consequent sediment ingress to the river).

The Wensum Restoration Strategy will continue to implement some of these actions at the remaining sites identified in the strategy. Individuals or groups interested in implementing their own projects should contact the Environment Agency as we would be interested to hear and may be able to offer advice.

Specific sites:

Gt Ryburgh would benefit from the planting of riparian trees to provide shade and cover for the species that reside there. Currently, insufficient cover is available for the present density of fish leading to some species moving out leaving those that remain subject to enhanced predation (see Gt Ryburgh comments/ interpretation section).

The results from **Sparham Pool, Lyng** indicate its importance for spawning and recruitment. Periodic gravel jetting of spawning gravels by the EA and club members prior to the spawning season has no doubt improved successful hatching and free swimming stages. However, the evasion strategy utilising deep silt berms (See Sparham pool, discussion section) and the diminishing number of adult chub, dace, roach and perch suggest a lack of suitable habitat to support juveniles through to adult. This section of river would benefit from enhanced habitat to support juvenile growth and suitable refuge for adults. It is recommended that this be addressed as soon as possible.

D/S Elsing Mill results show good numbers of adult chub across all surveys. Most of the large chub captured at this site are from under the extensive marginal sweet reed grass. It could be their preferred area for finding prey but the extent of reed grass will diminish in the colder winter months leaving them vulnerable. There is very little additional cover for large fish to use (See habitat section, D/S Elsing Mill). It is recommended that more cover should be provided at this site, by either additional tree planting or permanent floating margin structures.

Next scheduled Surveys

Scheduled surveys are 9 spatial surveys in 2021 along with monitoring restoration sites.

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/.