

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 100m² and biomass estimate of 1082 grams per 100m² 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

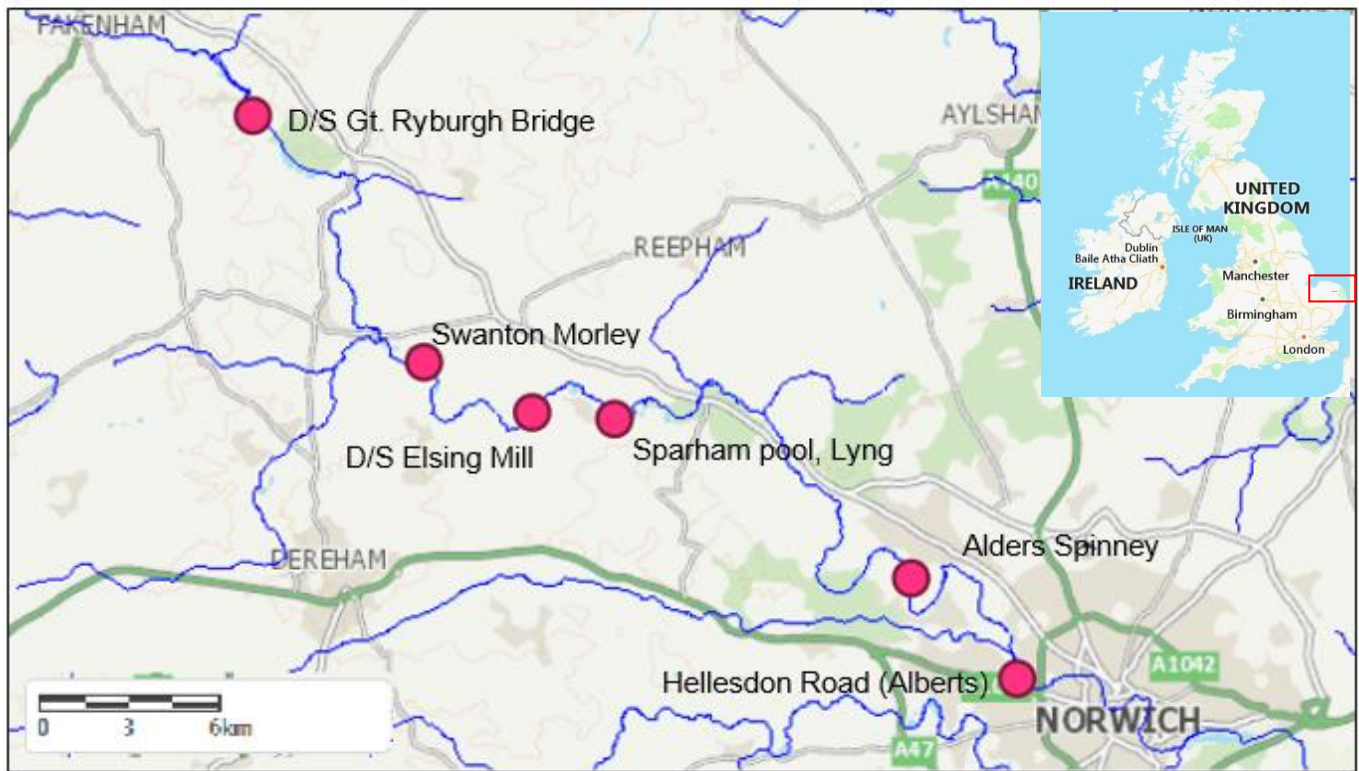


Figure 1. Map indicating location of the six annually surveyed sites in Norfolk and the UK. Sparham Pool, Lyng; is a recent addition to the 5 nationally driven temporal sites, initiated in 2016; funded by water resource revenue. © Environment Agency copyright 2016. All rights reserved. Ordnance Survey licence number 100024198.

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

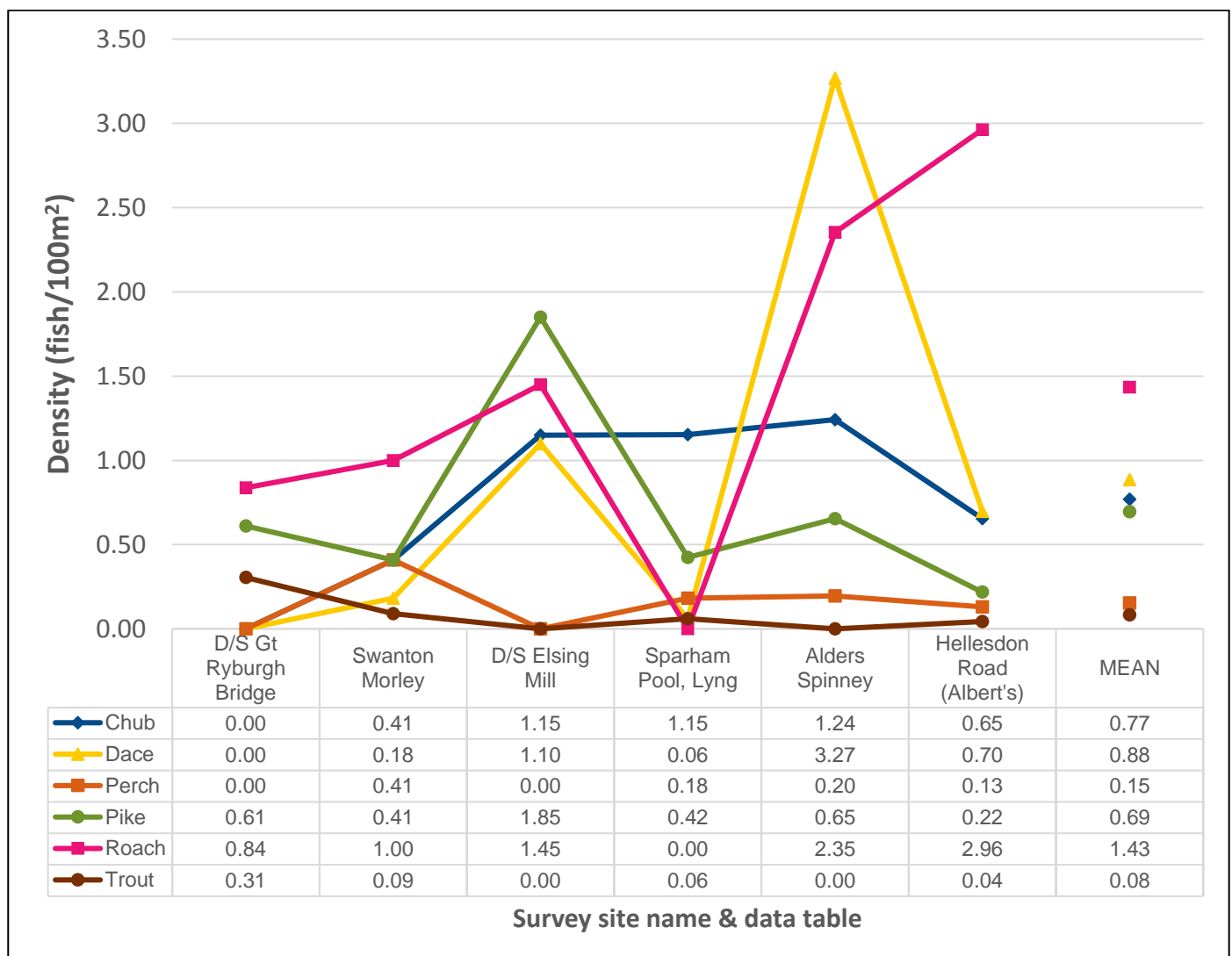


Figure 2. Density estimates of key species from each site. Estimates derived using fish over 99mm FL. Mean estimates across all sites shown for comparison (mean estimate of chub & pike lie on top of each other on chart).

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 (2.96 fish per 100 m²) is from Hellesdon Road, Alberts.
- Trout density peaks at the furthest upstream site (0.31 fish per 100 m²) 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 m²) is almost 3 times the mean estimate (0.15 fish per 100 m²)
- Pike density at D/S Elsing Mill site is the highest estimate across all sites (1.85 fish per 100 m²); 8 times higher than the lowest pike density recorded at Hellesdon Road, Alberts (0.22 fish per 100 m²).

2019 Biomass estimates

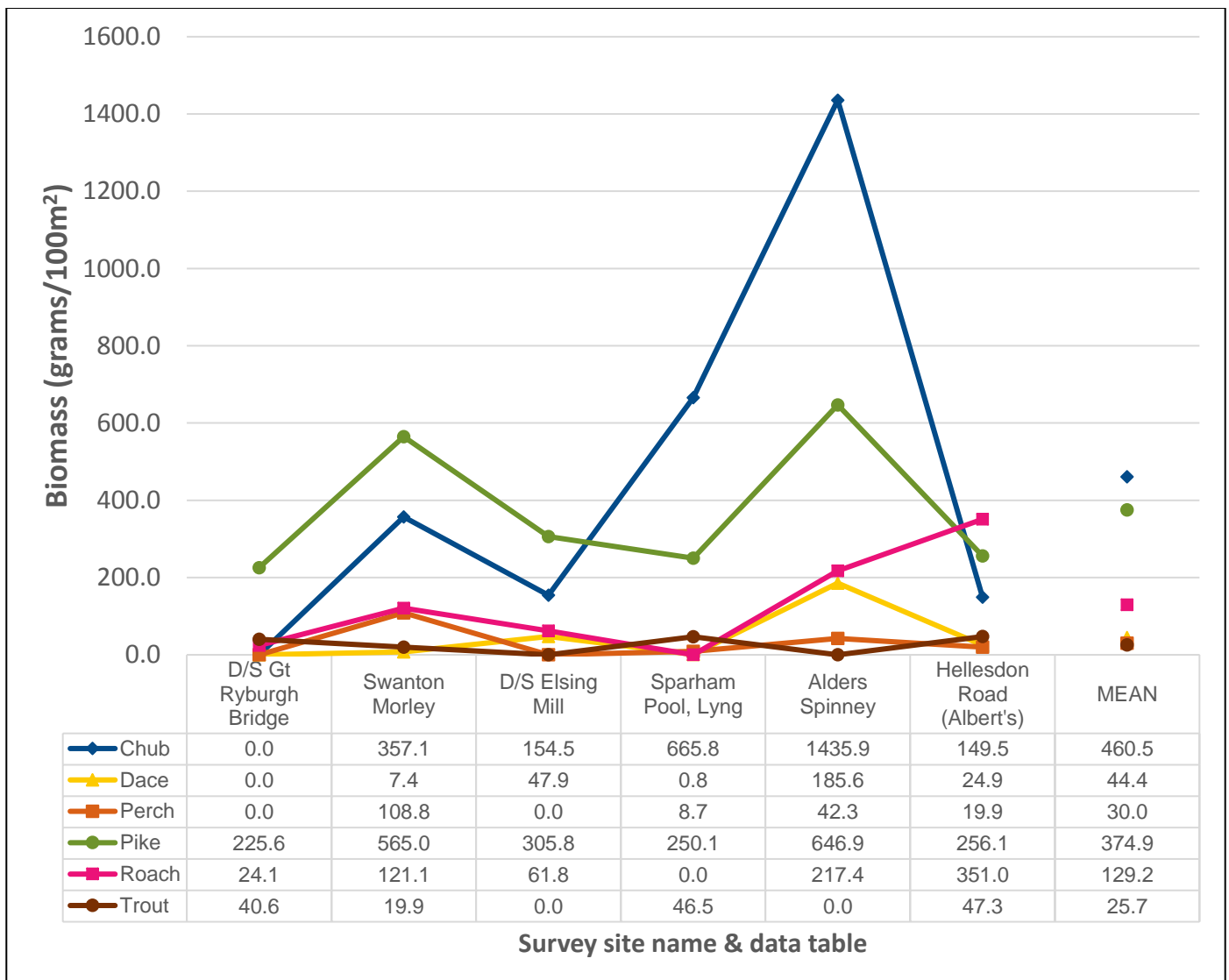


Figure 3. Biomass estimate values for key species at each site. Estimates based on fish over 99mm FL. Mean estimates shown are calculated using species data from all sites. Mean estimates for dace, perch and trout are similar and obscure each other on the chart.

Observations: (figure 3)

- Total chub biomass in 2019 across all sites (2763 grams per 100 m²) exceeds all other species
- Chub biomass estimate at Alders Spinney (1436 grams per 100 m²) 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 m²)
- Alders Spinney site has the highest combined biomass estimate (2528 grams per 100 m²) for the key species considered.
- Dace biomass estimate is highest at Alders Spinney (186 grams per 100 m²)

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 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, Swanton Morley was missing from the suite of sites in 2004, 2005, 2007 and 2008. To comparability, these years have been omitted from this analysis.

In 2017, a new site, Sparham Pool Lyng was added to the sites monitored yearly, bringing the total to 6. Data is included from this site in the whole river average for 2017 onwards and also for 2013, when the site was surveyed as part of the spatial network. This will affect the mean values but no consistent effect is visible.

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 m²) 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 m².

Long-term density estimates

Observations: long-term density estimates (figure 4)

Roach

- All-river roach mean densities vary considerably from year to year but there is no overall trend of increase or decrease.
- The mean 2019 roach density estimate for the central section of the River Wensum (1.43 fish / 100 m²) is slightly lower than the long-term mean for the species (1.80 fish / 100 m²).
- The 2019 roach density estimate is approximately half that of its peak estimate recorded in 2015 (2.77 fish / 100 m²) but is nearly 4 times the lowest estimate recorded in 2006 (0.38 fish / 100 m²).
- Although not as high as the peak density observed in 2015 a further peak is evident in 2012 (2.59 fish / 100 m²) and 2018 (2.03 fish / 100 m²) suggesting there may be a cyclical recruitment pattern.
- Long term roach density in the Wensum compares favourably to the Bure (central section) which has a long term mean of 1.3 fish / 100 m².

Dace

- The 2019 dace density estimate is above the long term mean for the first time since 2013.
- Dace density shows a similar variability to that of roach and with a somewhat similar pattern.

Pike & Chub

- The 2019 density estimates recorded for pike and chub: 0.69 & 0.77 fish / 100 m² are higher than their long-term means (0.61 & 0.69 fish / 100 m² respectively).

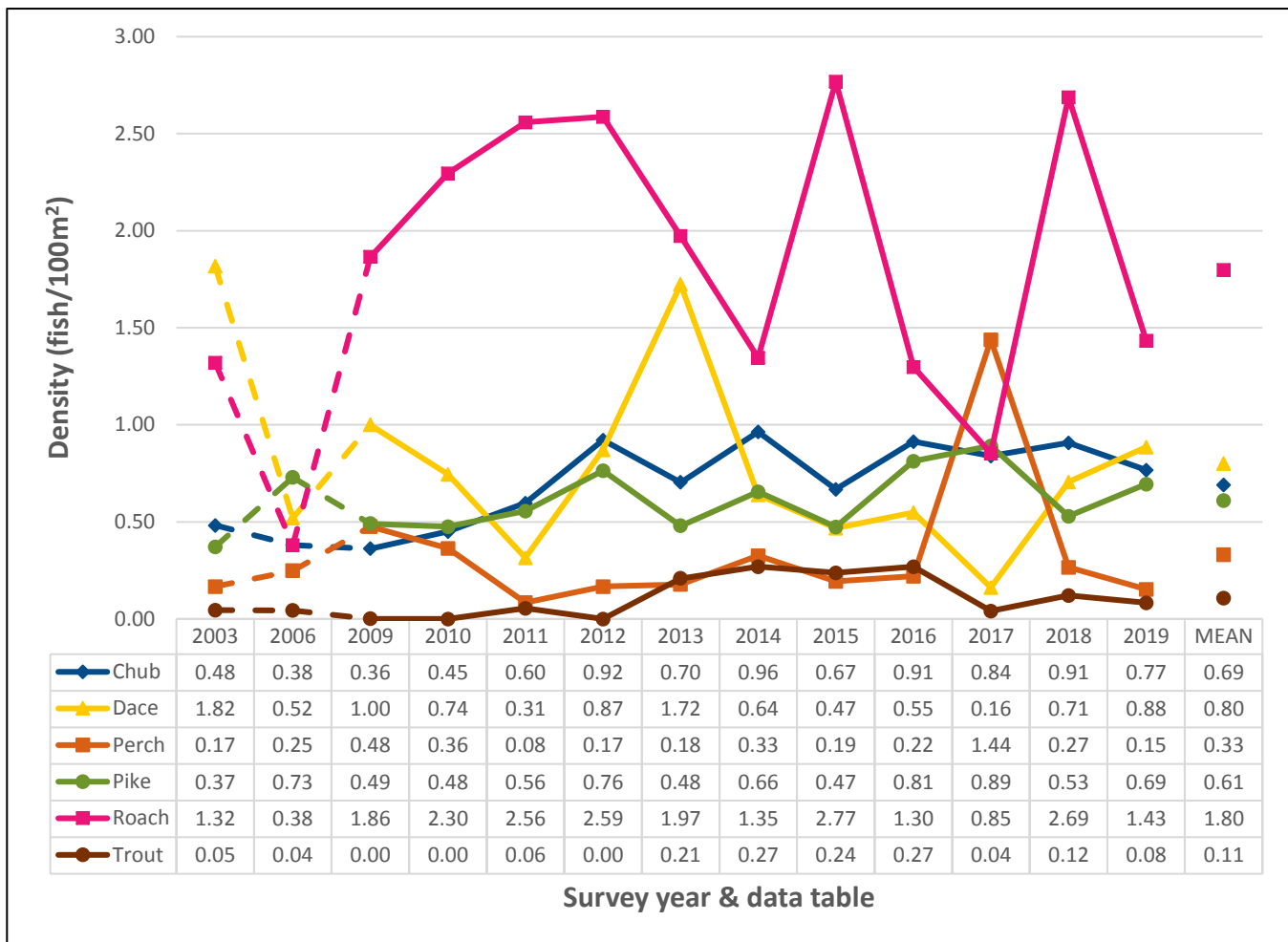


Figure 4. Long-term density estimates for key species from sites surveyed each year. Mean estimates shown for each species (mean estimate of pike and chub overlie each other).

- Throughout the period, density estimates for pike and chub are similar. In addition, the estimates exhibit a similar pattern with peaks and troughs mostly occurring at the same time.
- Density of both species stays relatively stable with all estimates within $\pm 50\%$ 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 survey period.

Perch

- Perch density in 2019 (0.15 fish / 100 m²) is less than half of the long-term mean: 0.33 fish / 100 m²
- The 2019 density estimate is the second lowest estimate recorded. The lowest occurred in 2011 (0.08 fish / 100 m²).
- Peak perch density, recorded in 2017 (1.44 fish / 100 m²) 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 0.08 and 0.48 fish / 100 m².

Trout

- Trout density estimate in 2019 (0.08 fish / 100 m²) is close to the long-term mean of 0.11 fish / 100 m²)
- Maximum average trout density recorded is 0.27 fish / 100 m².
- Long-term records show trout enjoyed a relatively strong period in 2013 to 2016 but that more recent estimates have been lower.
- This may be partly due to the dilution effect on the whole river average of the addition of Sparham Pool since 2017 as trout are very scarce at this site.
- 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 m² recorded in 2019 is slightly lower than the long-term mean (157.7 grams / 100 m²)
- The 2019 roach biomass estimate is over 5 times higher than the lowest biomass estimate, recorded in 2006 (22.2 grams / 100 m²)
- In recent year roach density and biomass estimates have followed similar patterns, indicating a stable population structure.
- Roach biomass does not shows any significant upward or downward trend.

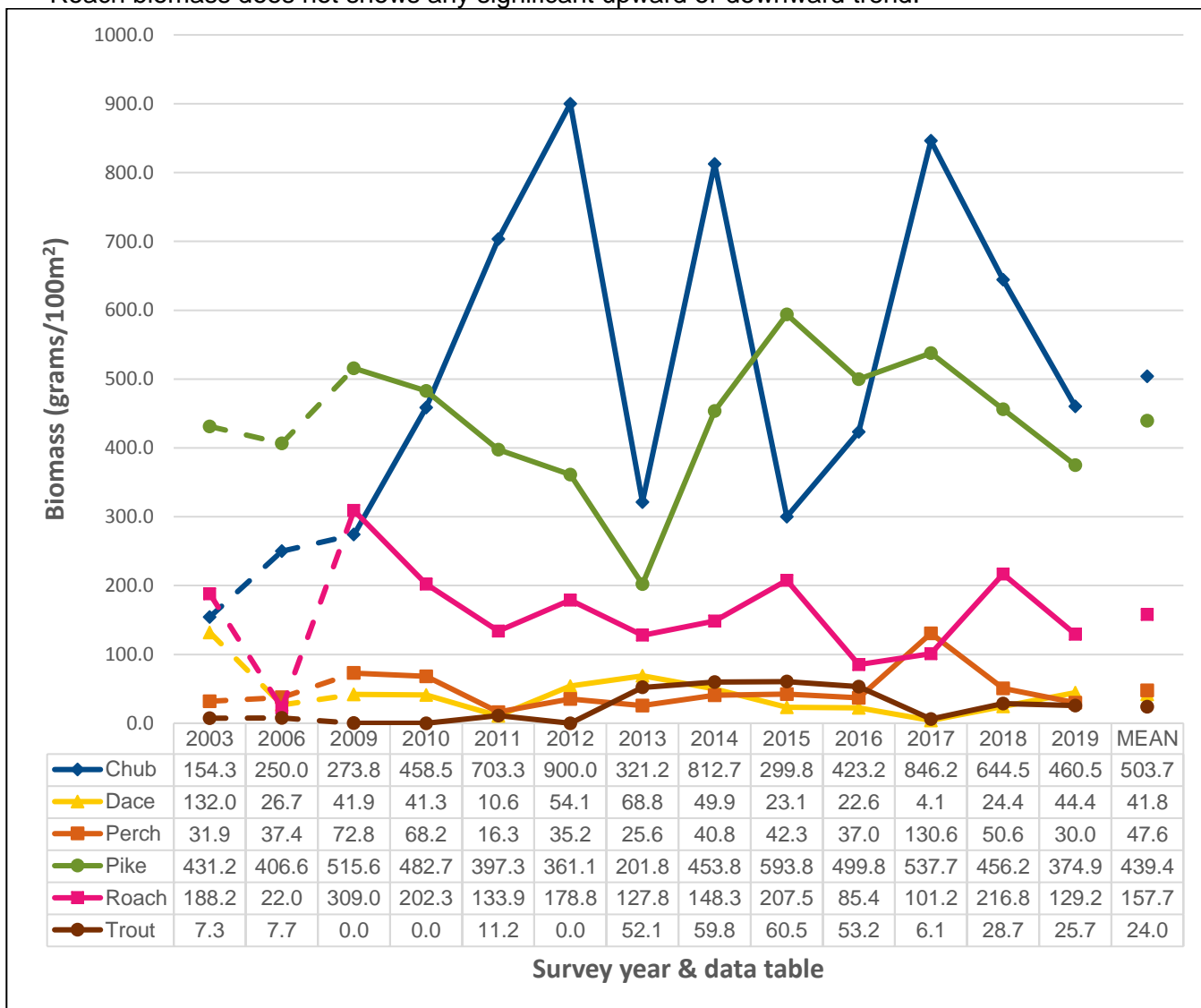


Figure 4. Long-term C&S biomass estimates for key species from sites surveyed each year. Mean values shown for each species.

Dace

- Dace biomass estimate for 2019 is 44.4 grams / 100 m², close to 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 m²
- After a high of 132 grams / 100 m² in 2003, dace biomass is relatively stable over the remaining period
- The relatively low values indicate the population is dominated by small individuals
- There is a trend of increase over the last 3 surveys.

Pike & Chub

- Pike and chub biomass dominate the survey results. Their respective long-term means of 439 and 504 grams / 100 m² each exceed the combined biomass of the 4 remaining key species.
- Chub biomass estimates show an upward trend over the period, however, large fluctuations are apparent. Peak estimate is evident in 2012 (900 grams / 100 m²) while lowest estimate is recorded in 2003 (154 grams / 100 m²).
- Pike biomass does not exhibit such large fluctuations as that of chub and show a stable trend. Peak estimate in 2005 is 594 grams / 100 m². Lowest estimate in 2013 is 202 grams / 100 m²
- 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 m²) is under two thirds of the long-term mean estimate of 48 grams / 100 m².
- With one exception, perch biomass is relatively stable; fluctuating between 16 and 68 grams / 100 m² over the 16-year period. The exception being 2017 when biomass estimate is 131 grams / 100 m².
- The pattern is very similar to density, indicating a stable population structure.
- Since peaking in 2017, perch biomass has reduced to the present 2019 value.

Trout

- Trout biomass estimate (25.7 grams / 100 m²) recorded in 2019 is close to the long-term mean biomass estimate of 24 grams / 100 m².
- The pattern is very similar to density showing similar sized fish are being caught.
- Trout over 99 mm FL are absent from the catch results in 2010 & 2012
- Since 2017 trout biomass has increased more than fourfold to the 2019 value of 25.7 grams / 100 m².

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.

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 and of almost constant depth, limited riparian vegetation and few overhanging trees. Substrate consisted mainly of sand and silt with little gravel visible. In-stream macrophytes were abundant but species limited. Surveyed area varied between 2003 ~ 2013; smallest area surveyed in 2012 was 140 m² due to the now bunded site and extensive weed growth. Survey area for the remaining 9 years exceeded 900 m² with a maximum survey area of 1460 m².

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 m². 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 m² (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 with 132 dace and over 250 minnow captured. Nine dace records exist in 2019; 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.

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

Observations: long-term density (figure 6)

Roach

- The 2019 roach density: 0.84 fish / 100 m² is well above the site long term mean (0.33 fish / 100 m²)
- 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 (3.3 fish / 100 m²) coincides with a reduced survey area for that year (950 m²)

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 in the form of smaller fish.
- Scale analysis of present and historic captures indicates a mixture of year classes with no discernible cycle evident.
- A dramatic peak recorded in 2013 coincides with the first survey since reconnecting the original river channel.

Chub

- Chub density is minimal at this site being recorded in 4 of the 18 surveys, most recently in 2018.
- Over the 16-year period 13 chub are recorded, 3 of which measure less than 99 mm FL.

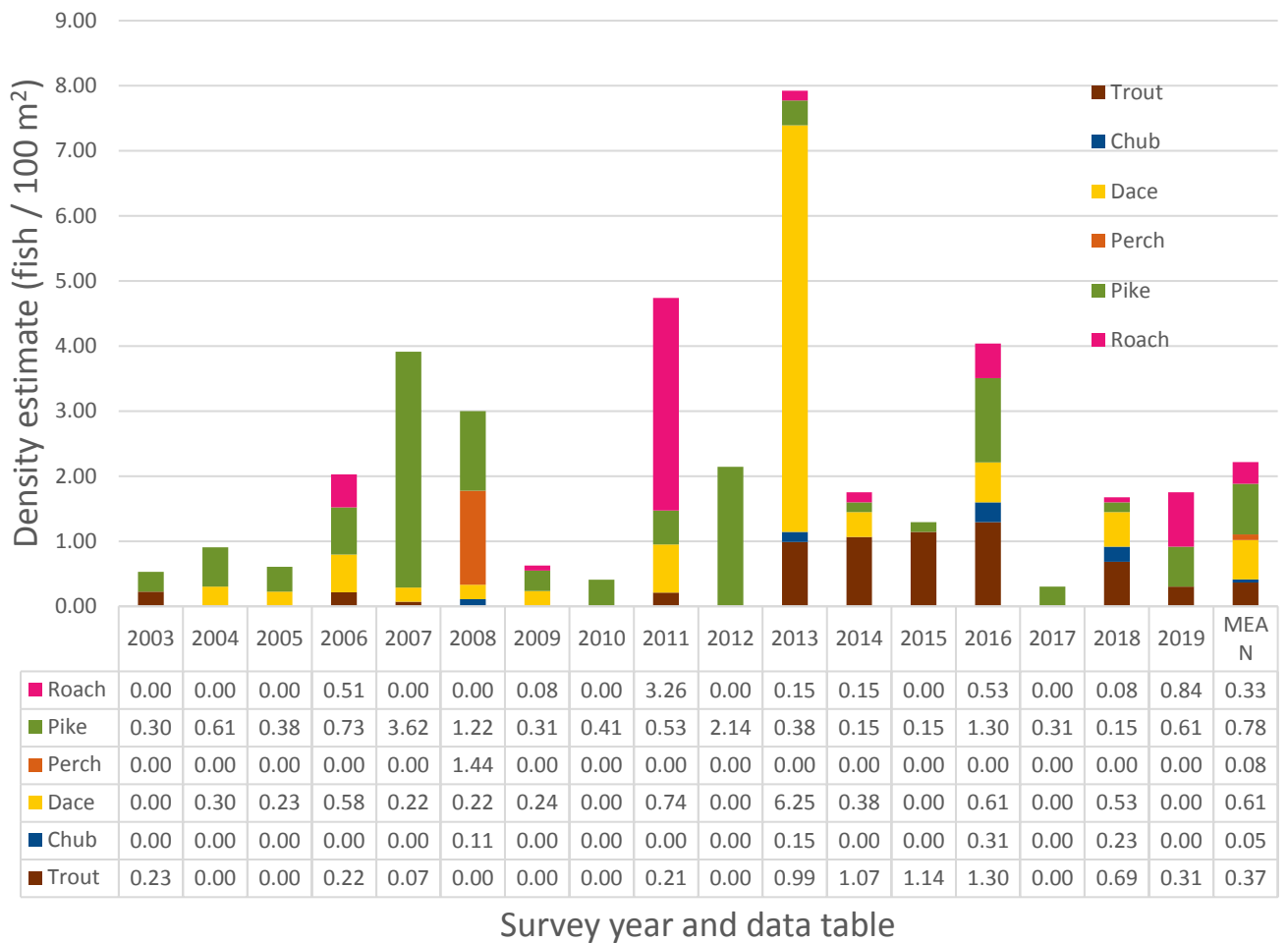


Figure 5. Long-term density estimates 2003 ~ 2019 for 6 key species over 99 mm FL at D/S Gt Ryburgh Bridge survey site

Pike

- Pike are present in all surveys
- The 2019 density estimate of 0.61 fish / 100 m² is 25% below the long term mean of 0.78 fish / 100 m²
- In 2010, 2012 and 2017, 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 m² 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
- 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 and at higher densities

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

Observations: long-term biomass (figure 7)

Roach

- The pattern for roach biomass follows that of density
- Roach never forms a significant proportion of the total biomass at this site.

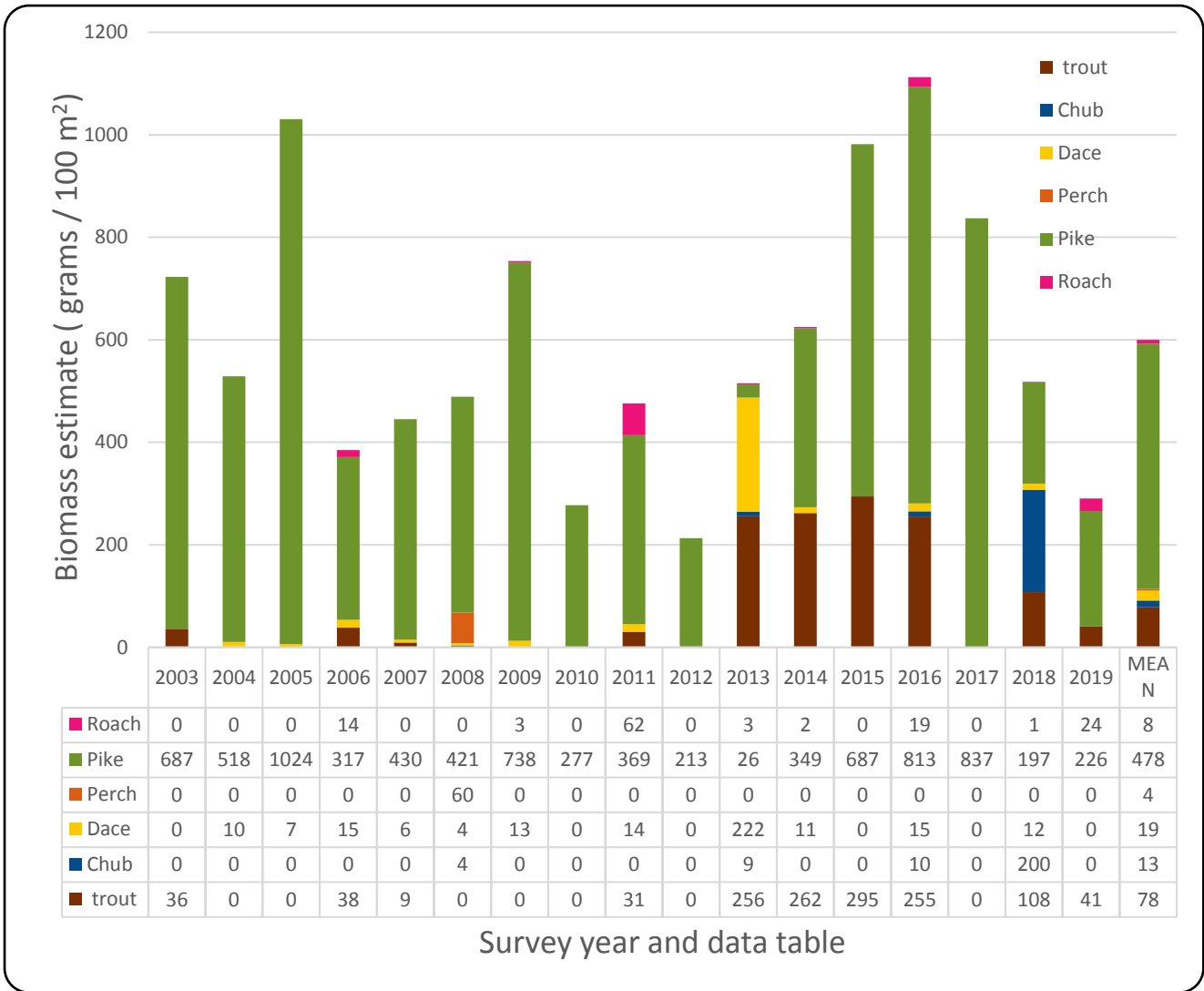


Figure 6. Long-term biomass estimates 2003 ~ 2019 for 6 key species over 99 mm FL at D/S Gt Ryburgh Bridge survey site

Dace

- As with density, the peak occurs in 2013, coinciding with the first survey since reconnecting the original river channel
- Excluding the 2013 estimate, dace biomass estimates is less than 16 grams / 100 m² at this site
- Long-term mean dace biomass estimate is 30 grams / 100 m².

Chub

- Despite low numbers (only 13 individual chub represent the species at this site), their long-term mean biomass is 56 grams / 100 m², higher than many species, due to their large size
- Chub are not represented in the 2019 survey results
- There is a pronounced peak in 2018 (200 grams / 100 m²), which equals that of pike for that year and indicates capture of a number of large adults
- Chub biomass in 2016 is 10 grams / 100 m² despite peak density recorded in that year (see figure 6). This indicates capture of only young chub that year and absence of large adults

Pike

- Except for 2013 & 2018, pike biomass vastly dominates the biomass at this site
- Pike biomass in 2019 is 225 grams / 100 m²; just under half of the long term mean estimate: 478 grams / 100 m²
- Pike seem to desert the site immediately after reconnection of the old meander in 2013 but then return to similar levels as previously
- In 2018 some pike seem to be displaced by the large chub that were caught that year

Trout

- The 2019 biomass estimate (41 grams / 100 m²) is a third of the long-term mean estimate: 133 grams / 100 m²
- 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 m²)

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 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 and 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 m² (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 m²) 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 were caught 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 smaller species recorded is, as always, an underestimate 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: 1.0 fish / 100 m² is below the long-term mean (2.7 fish / 100 m²)
- Roach captures of fish over 99 mm FL exist for every survey
- Density estimates vary quite widely but are frequently the most numerous species
- Mean density is much greater than that at Ryburgh Bridge (0.33 fish / 100 m²)

Dace

- Density estimate for dace in 2019 (0.18 fish / 100 m²) is less than the site long-term mean (0.58 fish / 100 m²)
- Dace density estimates for fish over 99 mm FL show no apparent cycle or long term trend at this site.
- Dace are recorded every year at this site, including 2006 when 29 dace below 99 mm FL are recorded.
- Scale readings indicate a healthy mixture of year classes with no discernible cycle evident.

Chub

- Chub density estimate in 2019 (0.41 fish / 100 m²) is 65% of the long-term mean for the site (0.64 fish / 100 m²)
- 2019 sees something of a recovery for the species at this site following 2 very low results when pike were the dominant predator.
- Scale analysis shows a mixture of year classes are present across the 13 surveys

Perch

- Perch density estimate; 0.41 fish / 100 m², recorded in 2019 is higher than the site long-term mean 0.31 fish / 100 m².
- In 2010 perch density estimate is at its highest value: 0.86 fish / 100 m²: over twice the long-term site mean
- Perch density estimates at the site are erratic, showing no discernible pattern across the 13 surveys

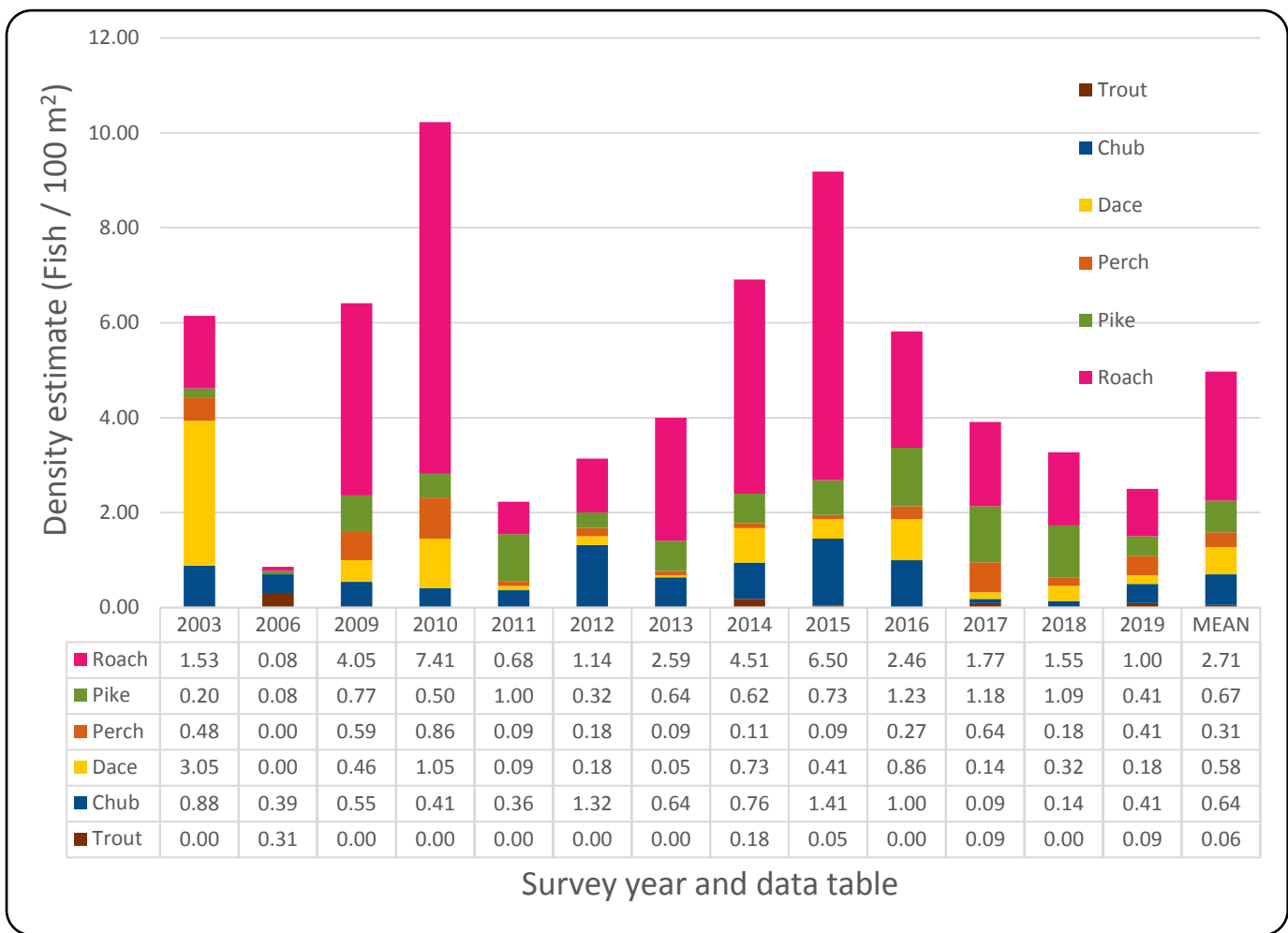


Figure 7. Long-term density estimates 2003 ~ 2019 for 6 key species over 99 mm FL at Swanton Morley survey site. Note survey schedule changed from 3 yearly to annual surveys in 2009.

Pike

- Pike are represented in every survey
- The 2019 density estimate of 0.41 fish / 100 m² is 57% of the long term site mean: 0.67 fish / 100 m²
- 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
- Their capture is erratic over these years
- The 2019 density estimate: 0.09 fish / 100 m² is above the long-term site mean: 0.06 fish / 100 m²
- Trout captured at the site are often identified as stocked fish, highlighted by the number of fin clipped or tags observed (but not those caught in 2019).

Long-term biomass at Swanton Morley survey site

Observations: long-term biomass (figure 9)

Roach

- The 2019 roach biomass: 121 grams / 100 m² shown is below the long term mean: 271 grams / 100 m²)
- 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 m²: biomass estimates remain above 400 grams / 100 m² for the same years.

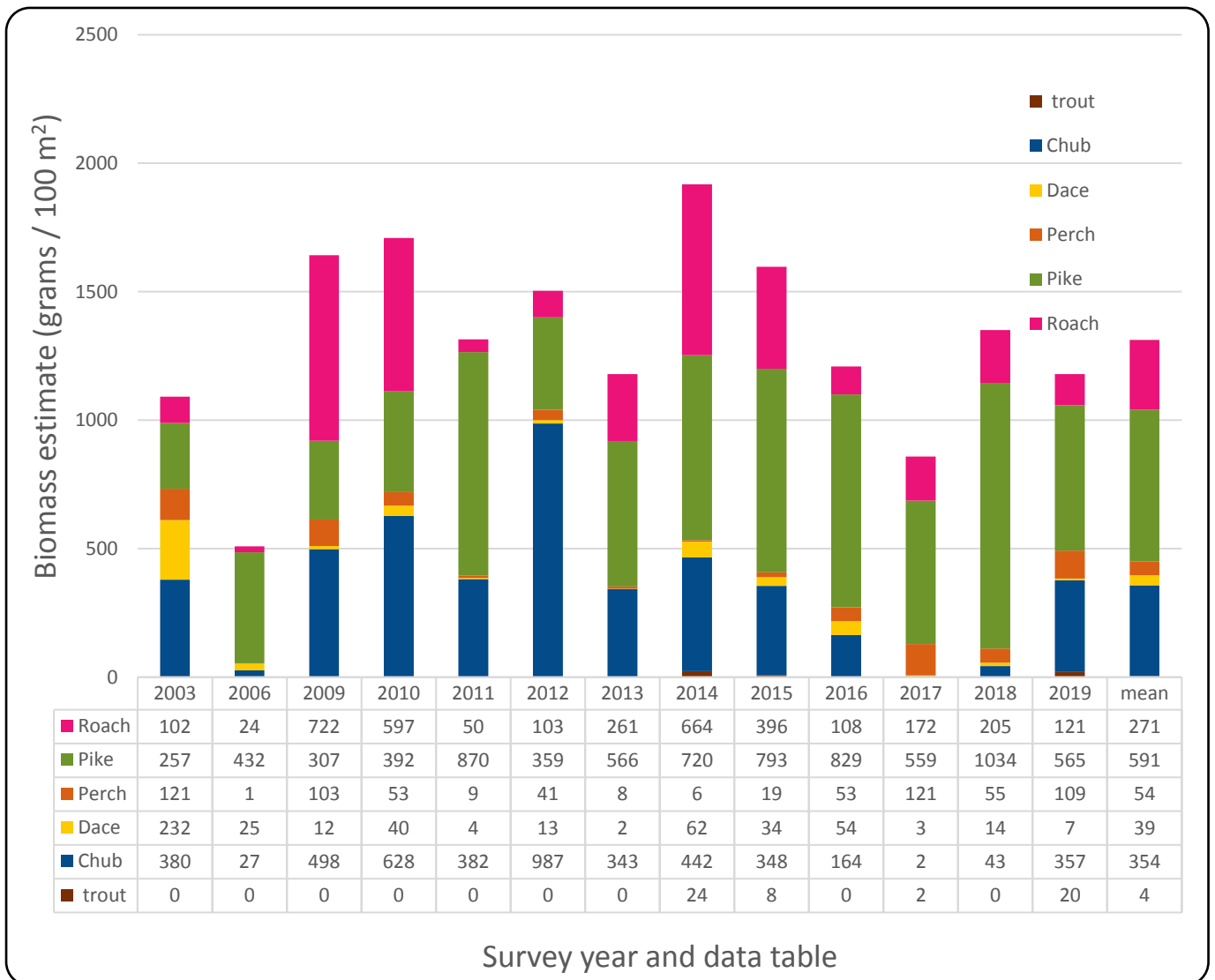


Figure 9. Long-term biomass estimates 2003 ~ 2019 for 5 key species over 99 mm FL at Swanton Morley survey site

Dace

- Estimated dace biomass in 2019 is 7.4 grams / 100 m²: less than the long-term mean for this site (39 grams / 100 m²)
- The 2003 biomass estimate (231 grams / 100 m²) significantly affects the long-term mean value at this site
- Excluding the 2003 estimate, dace biomass estimate peaks at 62 grams / 100 m²
- Except in 2003, the contribution of dace to the overall biomass at this site is low

Chub

- Estimated chub biomass in 2019 at this site is 357 grams / 100 m² this is on a par with the long-term site mean of 354 grams / 100 m²
- 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 m² (see figure 8). By calculation, each fish caught weighed on average; 890 grams (2lbs)
- Chub biomass is highly variable: 2 ~ 987 grams / 100 m². In some years it dominates the biomass eg 2012 and in others is all but absent eg 2017.

Perch

- Perch biomass estimate in 2019 (109 grams / 100 m²) is over twice the long-term site mean of 53.8 grams / 100 m²
- Perch biomass estimate at this site peaked in 2017: 121 grams / 100 m²
- Perch never forms a significant proportion of the biomass
- 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 565 grams / 100 m²; slightly lower than the long-term site mean: 591 grams / 100 m²
- Peak biomass estimate occurs in 2018: 1034 grams /100 m². Pike density in 2018 is 1.1 fish / 100 m² (see figure 8)
- Lowest pike biomass estimate at this site is recorded in 2003 (256 grams / 100 m²): 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.
- The 2019 biomass estimate (19.9 grams / 100 m²) is higher than the long-term site mean: 4.1 grams / 100 m²

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 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 peaks 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. These transfers explain the peaks and the reduction in years following suggests these higher biomasses are above the current carrying capacity of the site. 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. 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 perch is deep water with a coarse 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. An increase in 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 macrophyte 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 *Glyceria 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 m² (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 in 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 m² to over 3500 m². 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 these, 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.

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 m² is below the long-term mean (1.91 fish / 100 m²)
- Roach over 99 mm FL feature in the survey results for the last 13 years; since 2007 to date.
- The highest density estimate is in 2011 (5.2 fish / 100 m²)
- There is an absence or near absence of roach 2003 ~2007
- From 2008 onwards, numbers are variable with no obvious cyclical pattern

Dace

- Density estimate for dace in 2019 is on a par with the long-term site mean
- There are two significant peaks in dace density estimate, the first in 2003: 5.1 fish / 100 m² and second in 2004: 3.8 fish / 100 m². They were the dominant species in these years but have only been a minor component in the years since
- This is the opposite of the pattern for roach
- No discernible spawning or recruitment pattern is evident over the 17-year period.

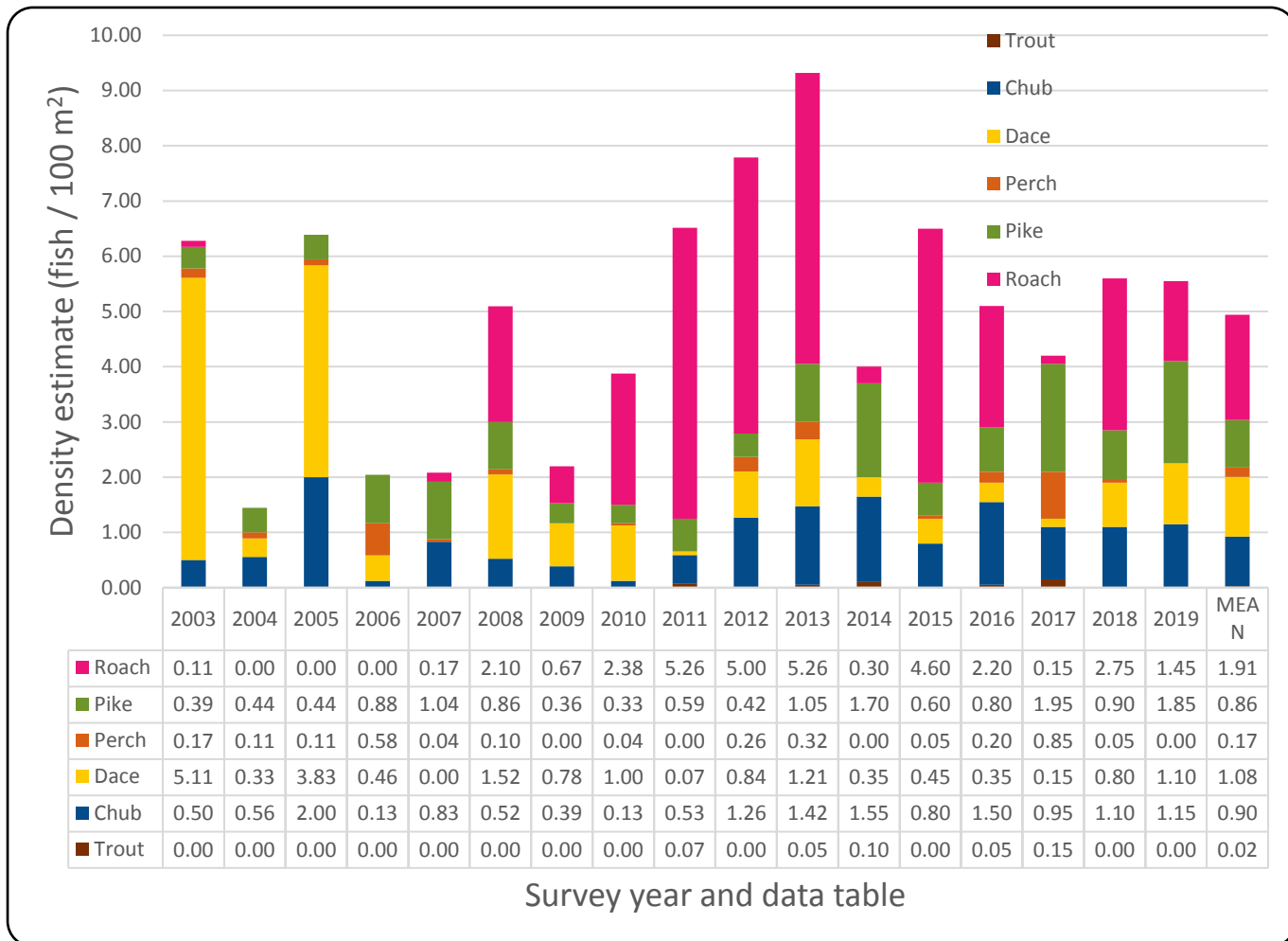


Figure 11. Long-term density estimates 2003 ~ 2019 for 6 key species over 99 mm FL at D/S Elsing Mill survey site.

Chub

- Chub density estimate in 2019 (1.15 fish / 100 m²) is slightly above the long-term mean for the site (0.9 fish / 100 m²)
- 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
- They have been more consistent from 2011 onwards

Perch

- Perch are absent from the 2019 survey. The site long-term mean for perch is 0.17 fish / 100 m².
- They are also absent in 2009, 2011 & 2014 although 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 present in all 17 surveys and less variable than other species
- The 2019 density estimate of 1.9 fish / 100 m² (the second highest estimate recorded) is over twice the long term site mean: 0.86 fish / 100 m²
- 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
- Trout were only caught in 5 of the 17 surveys
- Trout 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)

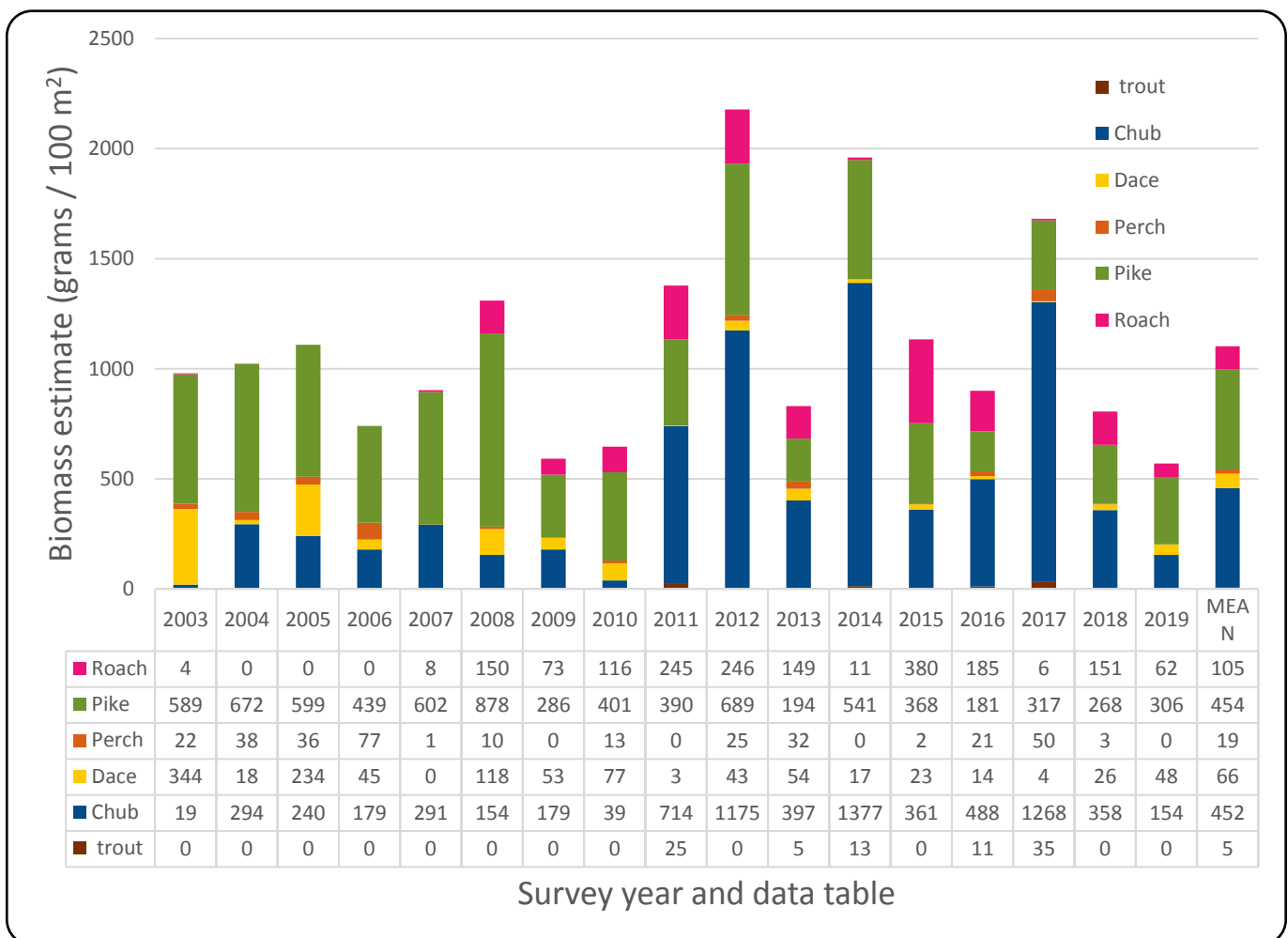


Figure 12. Long-term biomass estimates 2003 ~ 2019 for 6 key species over 99 mm FL at D/S Elsing Mill survey site.

Roach

- The 2019 roach biomass: 62 grams / 100 m² is well below the long term site mean: 105 grams / 100 m²)
- Biomass estimate is highest in 2015 at 380 grams / 100 m²
- The pattern is similar to density with very low estimates in the early years and erratic since
- Although often numerically dominant, due to their small size relative to species such as pike and chub, they form a much smaller proportion of the biomass

Dace

- Estimated dace biomass in 2019 is 48 grams / 100 m²: less than the long-term site mean estimate of 66 grams / 100 m²
- As with density, high values are seen in 2003 and 2005
- Discounting biomass estimates in 2003 and 2005, dace biomass estimates do not exceed 120 grams / 100 m² in any year.
- As with roach, they form a small proportion of the total fish community biomass

Chub

- Estimated chub biomass in 2019 at this site is 154 grams / 100 m², the lowest since 2010
- The long-term site mean is 452 grams / 100 m².
- There is a similar variable pattern to density
- There seems to be a step change in 2011 to higher biomass estimates. However, the 2019 result is lower and it remains to be seen if the population will bounce back

Perch

- Perch presence is not recorded in the 2019 survey. The long-term site mean is 19 grams / 100 m²

- Perch biomass estimate at this site peaked in 2006: 76 grams / 100 m²
- Perch are completely absent from 5 of the 17 surveys since 2003.

Pike

- Pike biomass in 2019 is 306 grams / 100 m²; two thirds of the site long term mean estimate for the species 454 grams / 100 m²
- Between 2003 and 2010 pike biomass estimate is the highest of all the species shown
- Since then pike biomass has tended to be lower, coinciding with the period that chub biomass has increased

Trout

- Trout are absent in 2019. The site long-term mean is 18 grams / 100 m²
- 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 numbers 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 and prey 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. Their presence is also likely to be affecting the key species reported here, such as roach.

Roach and dace seem to have swapped dominant position: prior to 2008, dace biomass and density estimates exceed those of roach while 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 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. This suggests 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 not stay here for long, even though scale analysis shows roach over 10 years of age exist at this site. Competition with crayfish for food or lack of submerged plants due to crayfish grazing could be some or all of the reason.

It is no surprise that perch are absent from the 2019 results (see table 5). 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, some suitable structure and weed growth were present.

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 which indicates 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 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.

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. 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 however there is a suggestion that pike biomass peaks a year or 2 after roach. Density estimates over the long-term data set are never high, however, biomass shows the small number of pike feed well.

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 for annual survey. 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 m². 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 pondweed, starwort and burr reed. 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 these, only stone loach has occurred since. 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 were caught. 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

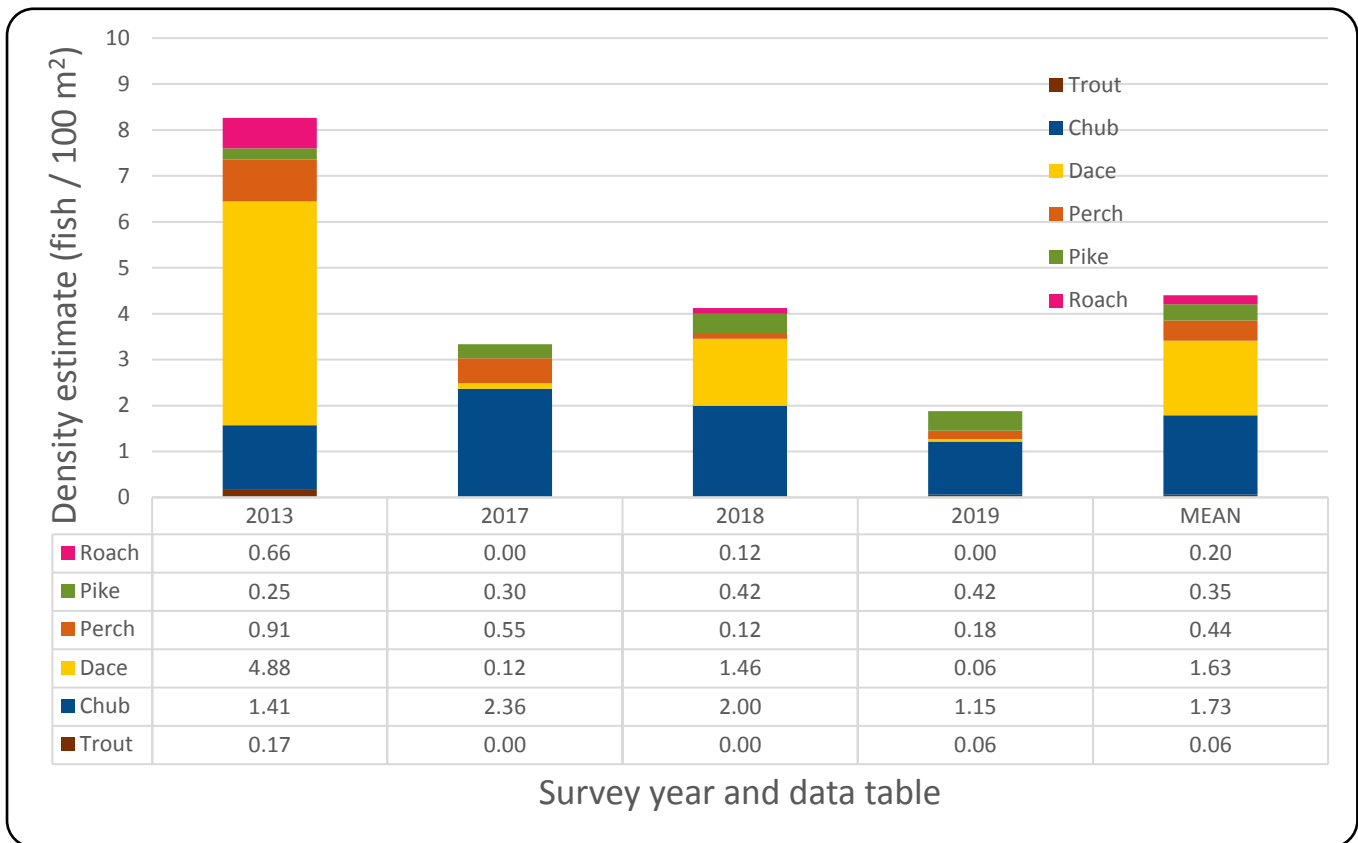


Figure 13. Long-term density estimates for 6 key species over 99 mm FL at Sparham Pool. Lyng survey site.

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 0.20 fish / 100 m²
- This is the lowest roach density of the 6 sites
- Roach density estimate is highest in 2013 at 0.66 fish / 100 m²

Dace

- Density estimate for dace in 2019 (0.06 fish / 100 m²) is considerably lower than the site long-term mean estimate (1.63 fish / 100 m²)
- Highest dace density recorded in 2013 is 4.88 fish / 100 m², one of the highest records for the middle Wensum.
- Dace over 99 mm FL are recorded each year at this site.
- Scale readings indicate a healthy mixture of year classes.

Chub

- Chub density estimate in 2019 (1.15 fish / 100 m²) is the lowest estimate noted for the site but is the highest density of the key species
- The site long-term mean estimate is 1.73 fish / 100 m² and highest density, in 2017, is 2.4 fish / 100 m².
- Scale analysis shows a mixture of year classes are present at this site

Perch

- Perch density estimate; 0.18 fish / 100 m², recorded in 2019 is lower than the site long-term mean 0.44 fish / 100 m².
- Perch are present in all 4 surveys
- In 2013 perch density estimate is at its highest value: 0.9 fish / 100 m²: over twice the long-term site mean
- Lowest perch density estimate occurred in 2018, dropping to 0.12 fish / 100 m².

Pike

- Pike are represented in all 4 surveys
- The 2019 density estimate of 0.42 fish / 100 m² is higher than the long term site mean: 0.35 fish / 100 m²

- There is a slight trend of increase but numbers are lower than at other sites

Trout

- Trout are present in the 2013 & 2019 surveys in low numbers
- 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)

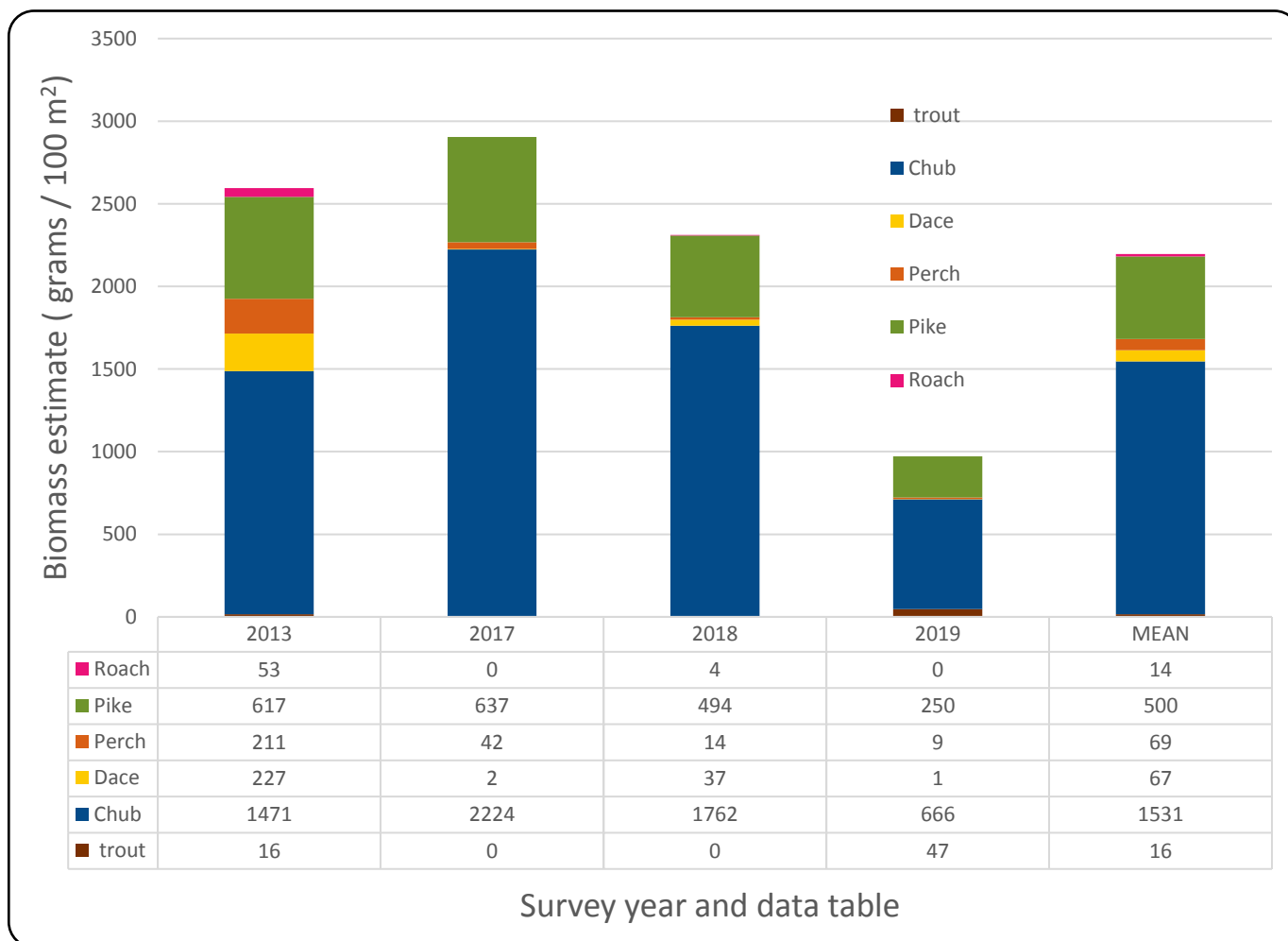


Figure 14. Long-term biomass estimates for 6 key species over 99 mm FL at Sparham pool, lyng survey site

Roach

- No roach over 99 mm FL were recorded in 2019 (see table 6), as such biomass estimate is not possible
- Biomass estimate is highest in 2013 at 53 grams / 100 m²

Dace

- Estimated dace biomass in 2019 is 0.8 grams / 100 m²: less than 2% of the long-term site mean estimate of 66 grams / 100 m²
- The highest biomass recorded occurred in 2013: 226 grams / 100 m² is 3.5 times higher than the long-term mean estimate.

Chub

- Estimated chub biomass in 2019 at this site is 666 grams / 100 m². The long-term site mean is 1530 grams / 100 m².
- The peak biomass estimate: 2224 grams / 100 m² occurred in 2017: lowest biomass estimate is recorded in 2019
- Chub biomass is higher at this site than all others and is much the highest of the key species

Perch

- Perch biomass estimate for 2019 is 9 grams / 100 m² significantly lower than the site long-term mean of 69 grams / 100 m²
- Perch biomass estimate at this site peaked in 2013: 211 grams / 100 m²

Pike

- Pike biomass in 2019 is 250 grams / 100 m²; half the value of the site long term mean estimate for the species: 500 grams / 100 m²
- The 2019 biomass estimate is the lowest of all the 4 surveys.
- Peak biomass estimate occurs in 2017: 637 grams /100 m².
- Pike takes second place after chub – between them they greatly dominate the biomass

Trout

- Trout biomass estimate in 2019 is 47 grams / 100 m². The site long-term mean is 31 grams / 100 m²
- 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. For instance, chub dominate the biomass here more than at other sites. In contrast, very few roach of any size have been caught. The nature of the site probably accounts for this balance as it lacks the extensive areas of deep slow flows favoured by roach but the mixed habitat suits chub and their hunting tactics.

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 was caught, aged at 3+ this fish. 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.

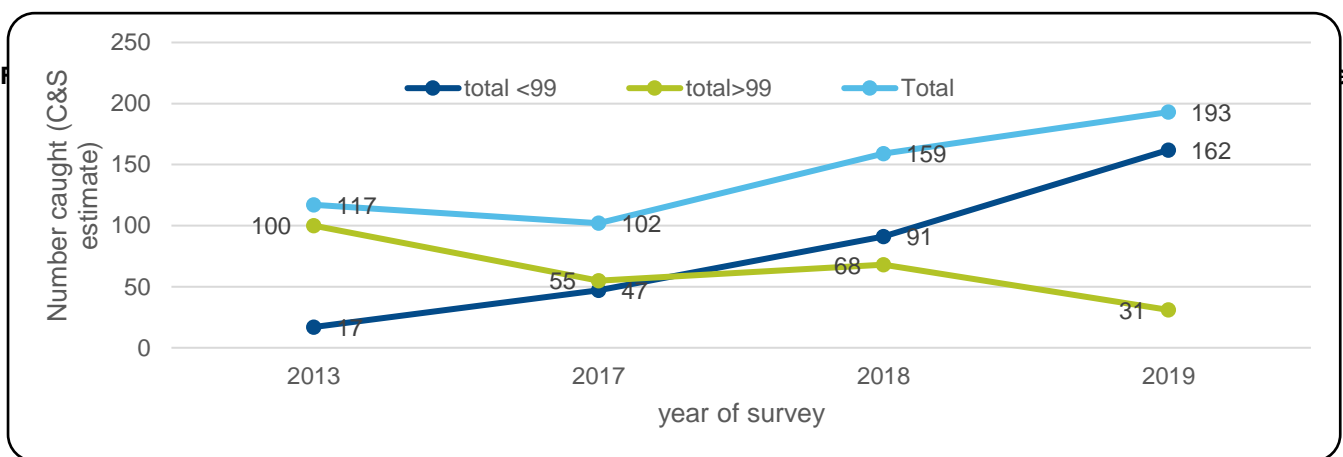


Figure 15. Total combined estimated number of fish, estimated number of fish over 99 mm FL and estimated number of fish less than 99 mm FL at Sparham pool survey site for 6 key species.

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 for the key fish species. 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 in-stream macrophytes. River width at this site is now stable at 9 metres. Bank morphology is largely unmodified and 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 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 burr reed, sweet grass and reeds 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 m²

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 also 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)

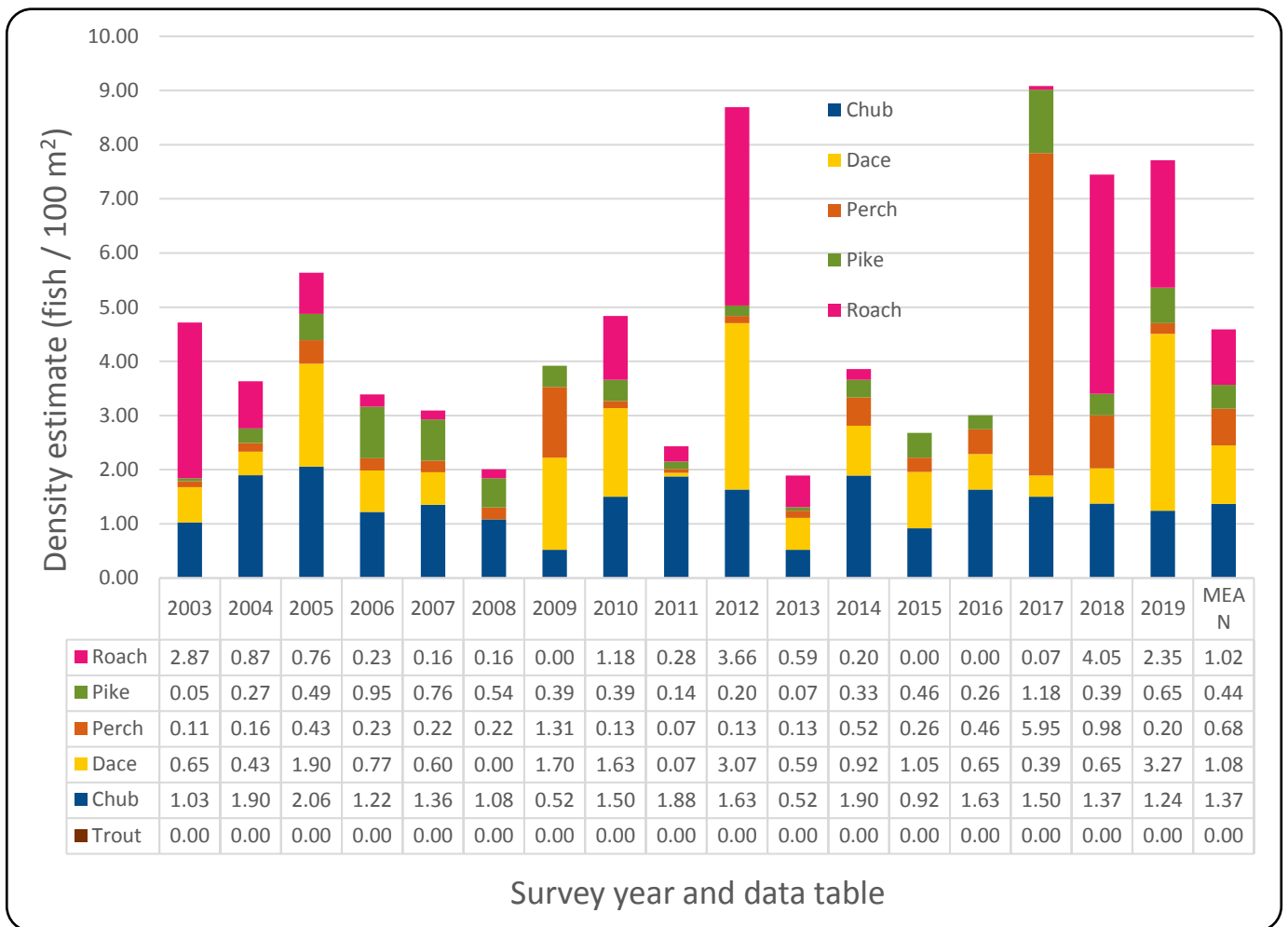


Figure 16. Long-term density estimates for 5 key species over 99 mm FL at Alders Spinney survey site.

Roach

- Roach density estimate at this site in 2019 is 2.35 fish / 100 m². Twice the site long-term mean roach density estimate (1.02 fish / 100 m²)
- Roach density is highly variable at this site
- Roach density estimate is highest in 2018 at 4.1 fish / 100 m²
- Roach over 99 mm FL were not recorded in 3 years (2009, 2015, 2016)

Dace

- Density estimate for dace in 2019 (3.27 fish / 100 m²) is the highest recorded of the 17 surveys. Site long-term mean density estimate is 1.08 fish / 100 m². This is a relatively good site for dace
- 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 (1.24 fish / 100 m²) is lower than the site long-term mean estimate: 1.37 fish / 100 m²
- 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

Perch

- Perch density estimate; 0.2 fish / 100 m², recorded in 2019 is lower than the site long-term mean 0.68 fish / 100 m².
- Perch are present in all surveys and this is one of their better sites
- Perch density estimate peaked dramatically in 2017 (5.95 individuals / 100 m²) almost a magnitude higher than the site long-term mean
- An indistinct 4 year cyclic pattern in perch density with 4 peaks in 2005, 2009, 2013 and 2017 seems to be evident

Pike

- Pike are present in all surveys
- The 2019 density estimate of 0.65 fish / 100 m² is higher than the long term site mean: 0.44 fish / 100 m²
- Highest pike density estimate occurs in 2017: 1.17 fish / 100 m². The same year as highest perch density occurs (see findings above).

Long-term biomass at Alders Spinney survey site

Observations: long-term biomass estimates (figure 17)

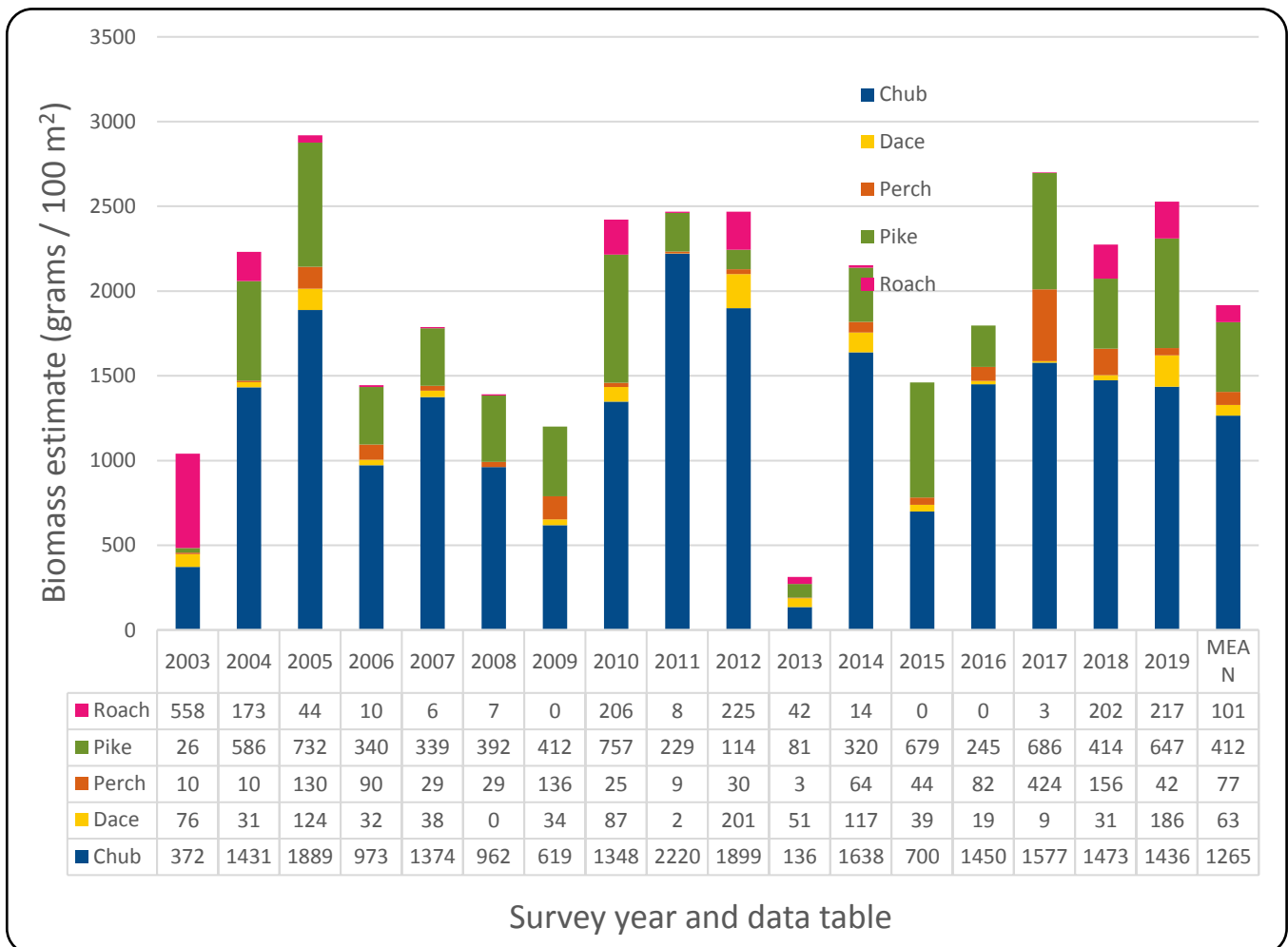


Figure 17. Long-term biomass estimates for 5 key species over 99 mm FL at Alders Spinney survey site.

Roach

- Roach biomass estimate in 2019 is 217 grams / 100 m², over twice that of the site long-term mean 101 grams / 100 m².
- In 2003 roach biomass estimate peaked at 557 grams / 100 m²
- Roach do not form a large proportion of the biomass estimate

Dace

- Estimated dace biomass in 2019 (186 grams / 100 m²) is nearly 3 times the site long-term mean estimate of 63 grams/100 m².
- The highest dace biomass estimate occurred in 2012: 200 grams / 100 m².
- Peaks in dace biomass estimates follow those of density: 2005, 2012, 2019.

Chub

- Estimated chub biomass in 2019 at this site is 1436 grams / 100 m². The long-term site mean is 1265 grams / 100 m².
- The peak biomass estimate: 2220 grams / 100 m² occurred in 2011: lowest biomass estimate is recorded in 2013: 136 grams / 100 m²
- 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.

Perch

- Perch biomass estimate for 2019 is 42 grams / 100 m²; a value lower than the site long-term mean of 77 grams / 100 m²
- Perch biomass estimate at this site peaked in 2017 the same year as peak density estimate: 424 grams / 100 m²

Pike

- Pike biomass in 2019 is 647 grams / 100 m²; higher than the site long term mean estimate: 412 grams / 100 m²
- Pike always plays second fiddle to chub.

Comments / Interpretation

Alders Spinney has a diverse fish community with 16 species being recorded over the survey period and 13 of these present in 2019. There are good numbers of the coarse fish species roach, dace and perch though each population is highly variable. The populations of predatory are healthy with chub dominant. The mean total fish biomass is highest at this site and Sparham Pool, Lyng. Both have varied habitat and good riverside tree cover.

In 2019, the 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 m², but this applies in 2008 as well. Yet in 2008, biomass estimate (1390 grams / 100 m²) although low compared to other years, is well above the biomass recorded in 2013 (313 grams / 100m²). The main 'missing' biomass is chub but pike were also very scarce. Happily results have returned to a healthy level since.

High pike biomass estimates 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 / 100m²).

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 km downstream. Heavy modification of the bank and channel using piling and straightened sections is evident along the 4.5 km 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 m²

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 a glide 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. In-stream macrophyte growth in this section tends to be dense and well anchored. Overhanging riparian plants are abundant and a long list of marginal plants is present.

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. 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, lamprey and stickleback. Both were observed during the survey but evaded capture.

Long-term density at Hellesdon road, Alberts survey site

Observations: long-term density (figure 18)

Roach

- Roach density estimate in 2019 is 2.96 fish / 100 m²; higher than the site long-term mean estimate: 2.66 fish / 100 m²
- Roach density estimate is highest in 2018 at 7.6 individual / 100 m²
- Roach feature in all 17 surveys at this site and the mean is the highest of all sites except Swanton Morley

Dace

- Density estimate for dace in 2019 (0.7 fish / 100 m²) is higher than the site long-term mean estimate (0.6 fish / 100 m²) and is the highest since 2015
- Highest dace density estimate in 2009 is 1.8 fish / 100 m². Lowest density estimate occurs in 2010: 0.04 fish / 100 m².
- Dace over 99 mm FL are present each year at this site. Scale readings indicate a mixture of year classes
- Several other sites have higher dace populations

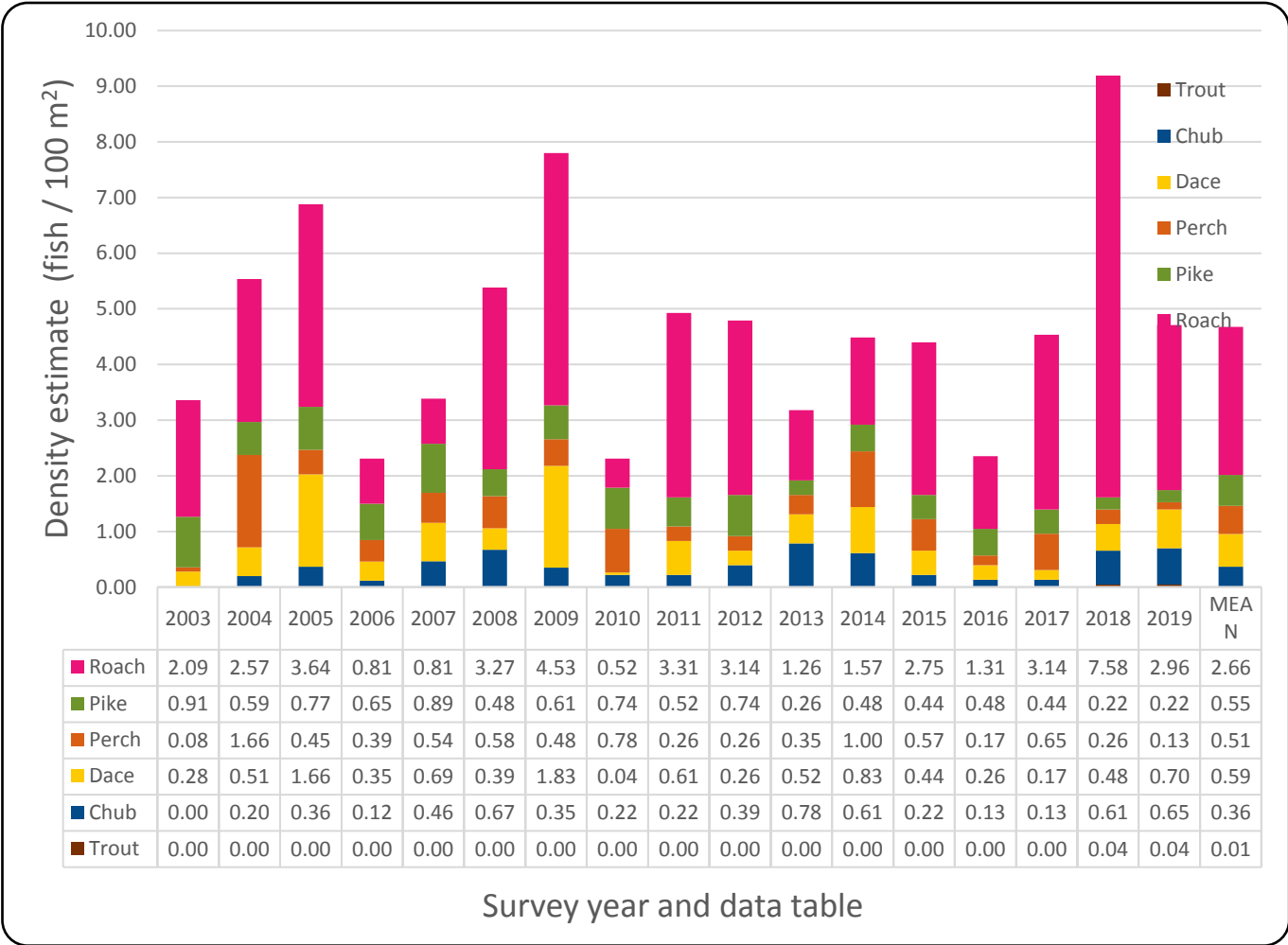


Figure 18. Long-term density estimates for 6 key species over 99 mm FL at Hellesdon Road, Alberts survey site.

Chub

- Chub density estimate in 2019 (0.65 fish / 100 m²) is higher than the site long-term mean estimate: 0.26 fish / 100 m².
- Scale analysis shows a mixture of year classes are present at this site
- Highest density, in 2013; is 0.8 fish / 100 m². Lowest density occurs in 2006: 0.11 fish / 100 m²

Perch

- Perch density estimate; 0.13 fish / 100 m², recorded in 2019 is considerably lower than the site long-term mean 0.51 fish / 100 m².
- Perch over 99 mm FL are represented in all surveys
- In 2004 perch density estimate is at its highest value: 1.7 fish / 100 m²: over three times the long-term site mean
- Lowest perch density estimate occurred in 2003 when the density estimate was 0.08 fish / 100 m².

Pike

- Pike are represented in all 17 surveys
- The 2019 density estimate of 0.22 fish / 100 m² is higher than the long term site mean: 0.55 fish / 100 m²
- Highest pike density estimate occurs in 2003: 0.9 fish / 100 m².

Trout

- Trout are present for the first time in the 2018 & 2019 surveys but at very low numbers (single specimens caught)

Long-term biomass at Hellesdon road, Alberts survey site

Observations: long-term biomass estimates (figure 19)

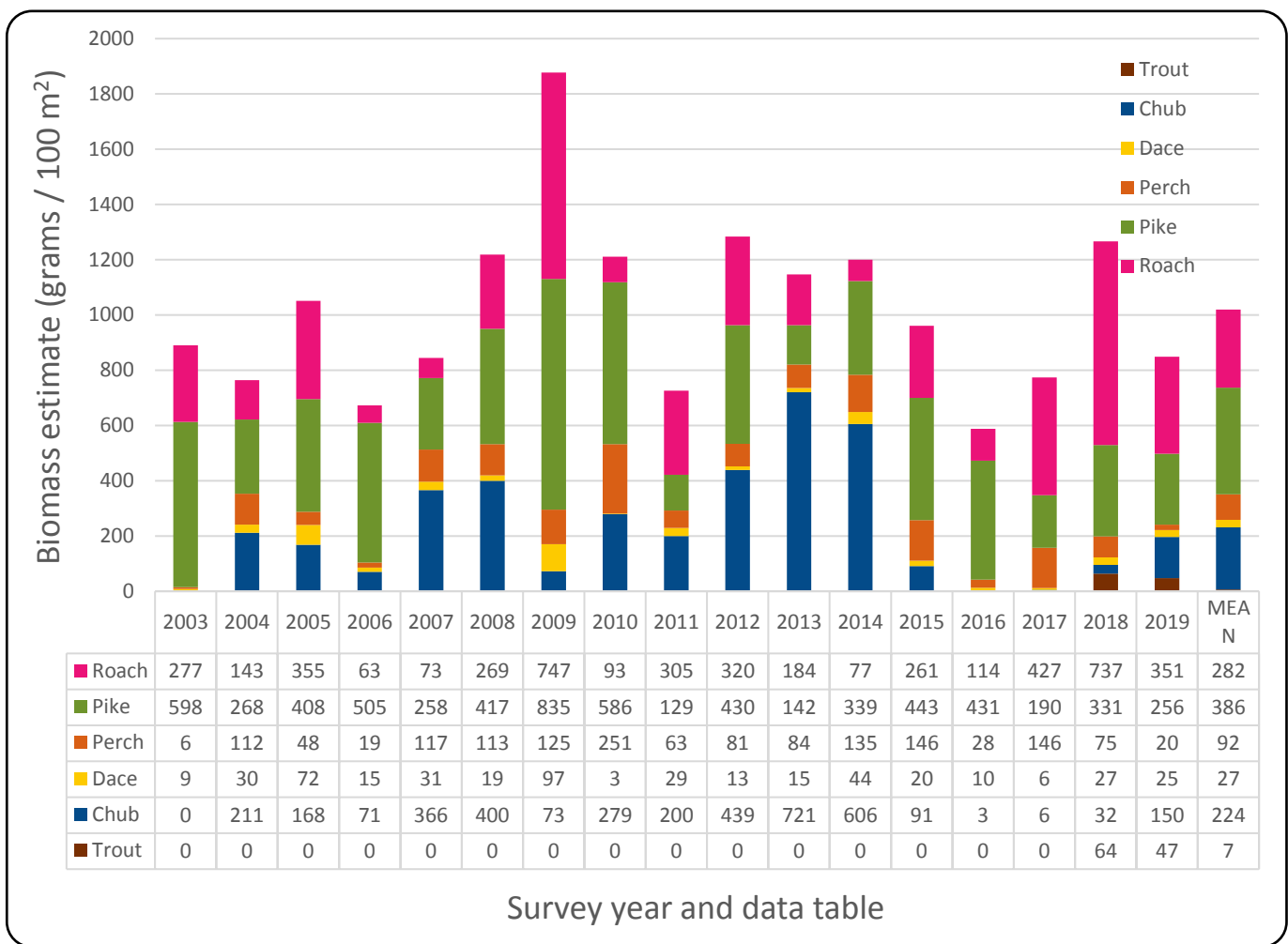


Figure 19. Long-term biomass estimates for 5 key species over 99 mm FL at Hellesdon Road, Alberts survey site.

Roach

- Roach biomass estimate in 2019 is 351 grams / 100 m²; 70 grams /100 m² higher than the site long-term mean
- Biomass estimate is highest in 2009 at 747 grams / 100 m²
- Distinct peaks occur in 2009 and 2018

Dace

- Estimated dace biomass in 2019 is 25 grams / 100 m²: close to the site long-term site mean estimate of 27 grams / 100 m²
- The highest biomass recorded occurred in 2009: 97 grams / 100 m².
- Despite the significant peak in 2009, dace has not done well in recent years.

Chub

- Estimated chub biomass in 2019 at this site is 150 grams / 100 m². The long-term site mean is 224 grams / 100 m²
- The peak biomass estimate: 721 grams / 100 m² occurred in 2013
- Chub biomass fluctuates widely at this site. The population apparently crashed after 2014 but is currently showing signs of recovery

Perch

- Perch biomass estimate for 2019 is 20 grams / 100 m² almost 4 times lower than the site long-term mean of 92 grams / 100 m²
- Perch biomass estimate at this site peaked in 2010: 251 grams / 100 m²

Pike

- Pike biomass in 2019 is 256 grams / 100 m². The site long-term mean is 386 grams / 100 m²
- The 2011 biomass estimate is the lowest of all the surveys: 129 grams / 100 m².
- Peak biomass estimate occurs in 2009: 834 grams /100 m².

Trout

- Trout biomass estimate in 2019 is 47 grams / 100 m², somewhat below the only other record in 2018

Comments / Interpretation

Records for 11 separate species of fish exist for the 2019 survey. This is relatively low diversity, however, 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 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 some years, roach biomass exceeds that of pike or chub (figure 19), which is not the case at the other sites. 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 and habitat are available to 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 were captured in 16 of the 17 surveys at this site but the numbers and sizes are variable. Biomass estimates mimic density estimates, however the 2018 ~ 2019 biomass estimates are significantly below the previous density highs in 2007~8 and 2013 ~14. This indicates that the mean size of chub in 2018 ~ 2019 has decreased recently. 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.

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 site's 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.

This is the best performing site in terms of perch biomass but they are still a relatively minor component of the fish community.

Pike density and biomass estimates have been low in the last 3 surveys; 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. There is no obvious reason for the poor results, however, populations have fluctuated over the survey period and will hopefully remain healthy into the future.

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 i.e. 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

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; invertebrates, 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.

However, despite relatively low densities of many species, biomass is high. A rivers' ability to support populations of fish is often monitored using standing crop (biomass). It is obvious from figure 5 that pike and chub biomass are dominant in the total biomass of the river as a whole. Pike and large chub are predators, relying heavily on an abundance of prey to enable their continued growth and lifestyle.

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. Sparham Pool, Lyng and Alders Spinney. The only site they do not form a large proportion of the biomass is Rybugh Bridge. 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. The large signal crayfish population at many sites in the river is thought to contribute to their success. As noted in comments above, growth rates of chub can be seen to increase once they are large enough to prey on crayfish. Also the chub populations has grown over the years, in line with anecdotal evidence of the expansion of the crayfish population. This supplements their more 'normal' fish diet and allows a high biomass to be supported. This high chub population may then

create pressure on prey species such as roach and depress their populations, as well as the other factors mentioned in this section.

Pike: Pike probably prey less on crayfish due to their different hunting strategy. Nevertheless they do well in the river and are a constant presence at each site in each year with relatively low fluctuations and show no trend of increase or decrease. The 2019 survey shows a continuation of a stable, healthy pike population.

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. 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.

Roach: roach density and biomass estimates fluctuate widely. This is probably related to their shoaling behaviour which means sometimes a shoal will be caught in the survey and sometimes missed. This means we must look for trends over longer periods or at more than one site. This holds true for the other species with this behaviour such as dace and perch. Over this time period there is little evidence of an increase or decline in roach populations. The exception is Elsing Mill where roach have been much more abundant from 2008 onwards.

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. Also, 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, 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 Helledon Road Alberts site suggest that a high proportion of adults are there as a consequence of fish being washed downstream in high flow events.

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.

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 is difficult but, once found, results indicate repeat captures of individuals 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.

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 are relatively low and unlikely to be detrimental.

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 creating a series of long ponded reaches. 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 EA/NE 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 provides 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

Although this reports shows a healthy fish population with good levels of angling interest, there is still room for improvement.

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.

Projects to introduce such features a further sites in the river are likely to benefit fish populations. These could also include:

- 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 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 may need to provide permission for aspects of the work and can 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 adulthood. This section of river would benefit from enhanced habitat to support juvenile growth and suitable refuge for adults.

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.

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/>.