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GALLOWAY GLENS

FISH: LOCH KEN

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Galloway Glens – Fish: Loch Ken

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Keywords

Loch Ken; coarse angling; crayfish; pike; citizen science.

Background

This study was commissioned by the Galloway Glens Partnership Project. Finance for the study was provided by Galloway Glens Partnership Project, Scottish Environment Protection Agency (SEPA) and Galloway Fisheries Trust (GFT).

Loch Ken in south west Scotland is a popular angling venue, particularly for coarse fish with competition and recreational anglers fishing for the diverse fish community present. This fishery has been important to the local economy for many years. During the mid-1990's North American signal crayfish were identified within the Kirkcudbrightshire Dee catchment and in Loch Ken itself. These non-native crayfish are firmly established within Loch Ken and in 2017; the Galloway Glens Project – *Fish, fisheries and angler survey in Loch Ken* – set out to make a robust assessment of the health of coarse fish populations residing in the loch, with particular focus on those utilised by anglers.

The 2017 report produced a series of recommendations, one of which was to continue to undertake monitoring of the coarse fish community. This report details the findings of coarse fish monitoring undertaken during spring 2019; through the sampling of catches from a single coarse fish match and a small pike competition held on the loch in March.

Main findings

- Loch Ken continues to be a popular fishery.
- The main fish species targeted by anglers on the loch are bream, roach, pike, perch and to a lesser extent dace and ruffe. Consideration of the overall health of these fish populations, including growth rates, suggested most were healthy.
- No particular concerns were identified when considering the growth rates of the fish collected in 2019.
- Bream, roach, perch, dace and ruffe can all be successfully sampled at Loch Ken matches, held mostly in the spring, autumn and winter. In addition, pike can be sampled during small pike competitions.

- Limited samples were collected from pike and perch. Both species are being sampled separately from matches by a trial group of dedicated bank and boat anglers, particularly to explore the theory that large perch have increased in numbers due to their successful exploitation of crayfish once they are four years and older.
- In 2019, the average bag weight recorded at a match increased at two out of three west bank sections, when compared to 2017 data. On the east bank, average bag weights were similar between years, except for Little Point, where 2017 produced a greater average bag weight than 2019.
- At present it appears that the coarse fish population in Loch Ken is able to support a viable and sustainable fishery in spite of the presence of a significant North American signal crayfish population.
- It is recommended that monitoring of fish populations continues during the autumn, when sampling can be undertaken at a large coarse fish match.

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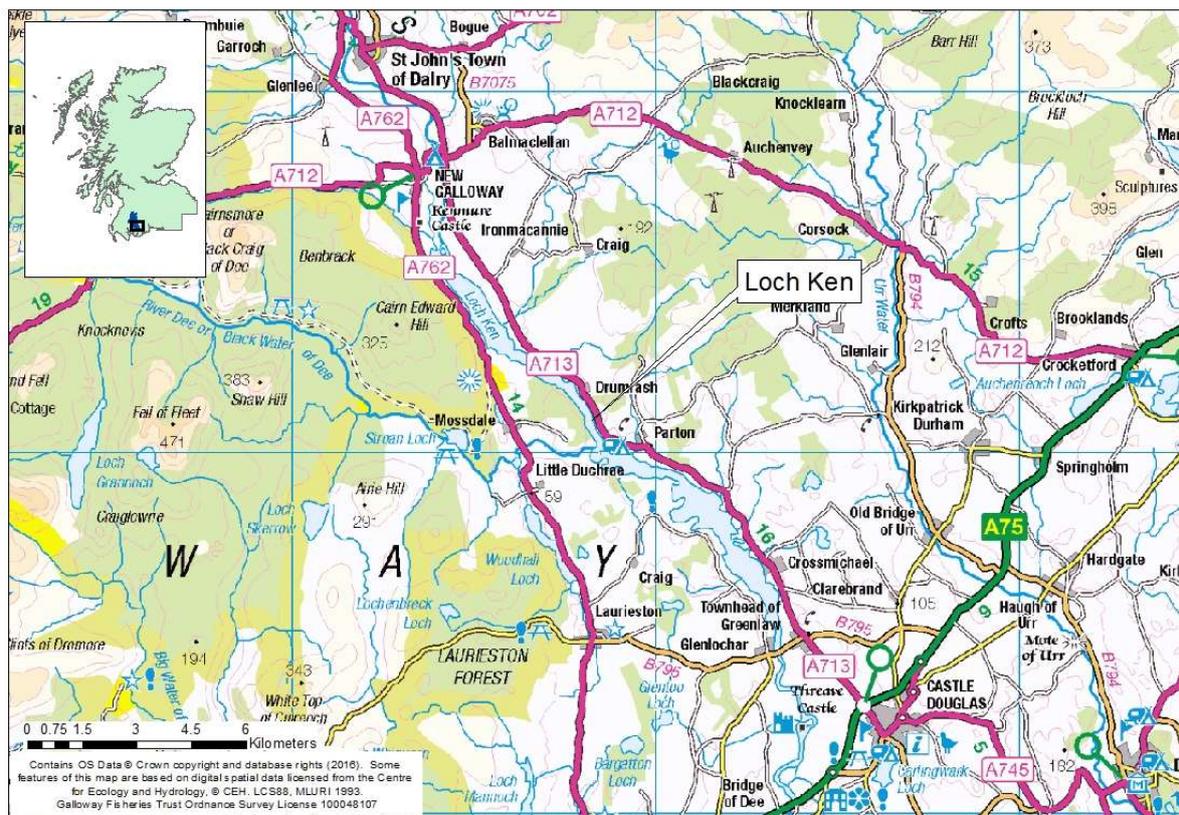
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1. INTRODUCTION

1.1 Location and management

Loch Ken is a 14.5 km long freshwater loch situated in Dumfries and Galloway, south west Scotland (see Map 1). The flow of the loch is dominated by two inflowing river channels; the Black Water of Dee from the west and the Water of Ken from the north. The river leaving the loch is known as the Kirkcudbrightshire Dee which flows for nearly 15 km before entering the Solway Firth near the town of Kirkcudbright. In 1929 the Galloway Water Power Act authorised the construction of The Galloway Hydro-electric Energy Scheme. The scheme was built between 1932 and 1936, which included the construction of Glenlochar Barrage. While the loch feature was part of the natural form of the river, the construction of the Glenlochar Barrage significantly increased the overall size of Loch Ken and nearly doubled its length.



Map 1: Location map of Loch Ken

The control barrage at Glenlochar allows water to be stored in Loch Ken to assist with power generation further downstream at Tongland Power Station. There are long-standing operating procedures for the barrage which manage water levels in the loch. These procedures have been established to meet and accommodate a range of interests not solely related to power generation. For example, the barrage gates are closed when the loch level drops to a specified height in order to protect the ecology of the wetlands and the amenity value for the many users of the loch. There are no specific provisions for compensation flow volumes below Glenlochar. Under increased flow conditions the gates will typically be fully open allowing water to flow unimpeded through Loch Ken.

The villages around Loch Ken include Glenlochar at the south, Laurieston and Mossdale on the west bank, and Crossmichael and Parton on the east bank. The village of New Galloway lies immediately to the north.

1.2 The fishery

The Kirkcudbrightshire Dee was known historically for supporting excellent runs of salmon of which high numbers were caught by a combined rod and net fishery. Andrew Symson in 1823 wrote in the 'A large description of Galloway' that *'This river [Dee] is abundantly plenished with excellent salmon'*. In 1909, William L Calderwood wrote in his book 'The salmon rivers and lochs of Scotland' that Loch Ken was only about four miles long and the *'sluggish stream that flow from it'* formed a confluence with the Black Water below Parton. *'The slack loch-like water between Parton and Crossmichael is a stronghold of pike A systematic war should be waged against these wretched fish when they spawn amongst the weeds in the spring, and all the little boys in the neighbourhood might set pike trimmers with advantage'*. In 1774 it is reported that a huge 72 lb pike was caught by John Murray in Loch Ken. There are various accounts of the bait used with some suggesting a large fly made out of peacock feathers, live bait or spinning. One record even suggests the bait used was a dead duck! Another large pike was recorded in 1904 which was found emaciated and dying at the edge of the loch but still was weighed in at 39 lb.

The increased size of Loch Ken following the construction of the Glenlochar Barrage would have made the water even more suitable for the resident pike population. The Dee District Salmon Fishery Board (DDSFB) and Dee Fishery Association supported a gill netting programme in Loch Ken aimed at reducing predation of salmon and trout. Many large pike were culled including one just over 35 lb in 1935. The Board ceased netting many years ago.

As interest in pike angling grew and became more accessible and affordable for anglers, Loch Ken became a popular venue for pike anglers who could easily fish the loch from both the shore and boats. In 1972 a visiting German Kurt Vogel caught a pike of 40 lb 4oz while spinning for salmon in Loch Ken. It was weighed officially on post office scales. The loch continues to be recognised as a venue for catching good sized pike and is considered to be the second most popular pike fishing water in Scotland after Loch Lomond. In Dumfries and Galloway, Loch Ken is recognised by anglers as the prime location for pike angling of the region both due to the quality of its pike catches and angler accessibility.

Although the loch lacks some migratory fish (eels and lamprey species) due to Tongland fish ladder being designed for salmon only, it holds one of the most diverse fish populations of any river system in Scotland. Many of the species present are not considered native to Scotland and appear to have been introduced as unused pike baits.

Easy access and affordable fishing is offered at various points around Loch Ken and this has made it popular for anglers fishing for many of the species present - anglers report catching good numbers of pike, perch, dace, roach, ruffe and bream. Match angling has been popular on the loch for many years and historically it was known as a renowned roach fishery which was particularly popular with English anglers. As additional fish species have been introduced to the loch, such as dace and ruffe, the fish species caught during matches has changed over time and although the roach population appears to have reduced the catches of bream have grown and in ideal conditions bags of 80 lb are reported in the angling press.

The importance of the fishery to the local economy is significant. In a 2009 Dumfries and Galloway Council (DGC) study it was found that 'Loch Ken and the angling it supports' was worth between £273,321 and £553,651 per annum (Cameron 2010). The protection and enhancement of the economic value of the fishery to the local economy is, therefore, important.

1.3 North American signal crayfish

In Dumfries and Galloway the first record of the non-native invertebrate North American signal crayfish (*Pacifastacus leniusculus*) (referred to as signal crayfish in the rest of the report) was made in two tributaries of the Kirkcudbrightshire Dee in 1996 (Maitland 1996; West Galloway Fisheries Trust 1996 and Sinclair & Ribbens 1999). By 2004 signal crayfish were present in the Water of Ken (between Loch Ken and Glenlee) and were starting to be reported as a nuisance by anglers in Loch Ken (Ribbens & Graham 2004). In recent years, particularly since the mid 2000's, there has been an increasing number of complaints made to Galloway Fisheries Trust (GFT), Scottish Environment Protection Agency (SEPA) and Scottish Natural Heritage (SNH) from anglers stating that they were catching numerous signal crayfish as by-catch when pike angling in Loch Ken. These fishermen also reported that it was becoming increasingly difficult to successfully pursue their activities due to bait interference from signal crayfish.

In 2009 the Scottish Government funded a five month trapping project on Loch Ken which examined the practicality and success of large scale signal crayfish trapping on a large water body, detailed the crayfish distribution within the loch and gathered a range of information on the population present (Ribbens & Graham 2009). The study confirmed both that large numbers of signal crayfish could be trapped in Loch Ken but also that this was expensive and could not eradicate signal crayfish from the loch.

Distinct from angling, it is unclear if and how the signal crayfish population has impacted upon the fish populations in or ecology of Loch Ken. There are, however, many documented concerns relating to their potential impact on fish species in particular due to: their burrowing activity in banksides, competing for habitat, grazing pressure on aquatic plants and predation on invertebrates, fish and fish eggs (Maitland et al. 2001, Maitland 1996, Sibley in Rogers & Brickland 2000).

Angling is affected by the presence of the signal crayfish, largely through interference with fishing baits. The DGC study conducted in 2009, found that '50% of the anglers surveyed felt that less signal crayfish in the loch would improve their experience' and rated it their top priority to improve the fishery (Cameron 2010). In the same study, New Galloway Angling Association (NGAA) reported a significant fall in the value of Loch Ken ticket sales between 2002 and 2009 due to the negative publicity surrounding the presence of signal crayfish in the loch.

In 2016 SNH and SEPA commissioned a study on Loch Ken to investigate the practicality of using a range of survey options (including angler interviews) which could be deployed to gather information on fish populations present (Galloway Fisheries Trust 2016). Within that work, of 35 anglers interviewed, eight stated they felt the signal crayfish were a negative aspect of the fishery and 14 stated that removing the signal crayfish would improve the fishery. Further to this study, of the 105 anglers who completed an angler interview in the 2017 project '*Fish, fisheries and angler survey in Loch Ken*', 14% of anglers included feedback that signal crayfish negatively impacted their angling experience on Loch Ken.

It is not possible to eradicate signal crayfish from Loch Ken.

1.4 2017 study

Within the Galloway Glens commissioned report '*Fish, fisheries and angler survey in Loch Ken*' (2017), three Loch Ken coarse fish matches were sampled during winter and spring time. The second match, sampled at the end of March, was considered best placed for future monitoring, because; fish were more active at this time of year and therefore more easily caught, day length was increasing and allowed for some of the processing to be carried out in light, and fish had not dispersed as widely to undertake spawning (bream had been

unattainable during the Spring Festival that was sampled in April 2017). From the 827 fish sampled at the match in 2017, ~30% were bream, 41% were roach, 6% were perch, 17% were dace and >6% were ruffe. Condition factors calculated for each of these species were >1 except for dace, where a few specimens were found with k values <1. In total, 52 scale samples, gathered by GFT during the matches attended, during seine netting activities and taken by anglers fishing outwith the matches, were analysed for fish age by the Environment Agency (EA). Bream were aged as 3 to 13 years old; roach as 1 to 13 years old; perch as 2 to 7 years old and dace as 1 to 6 years old. Nine pike scale samples, obtained during seine netting activities and donated by anglers fishing outwith the matches, returned results of pike up to 11 years old.

1.5 This study

To continue to monitor key fish populations of Loch Ken; this study will repeat sampling catches at the March Loch Ken coarse fish match, trial the sampling of pike at a small pike competition and establish a small sampling team of bank and boat anglers who target pike and perch on the loch. The data collected during this study will continue to inform future management of Loch Ken as a popular coarse fishery.

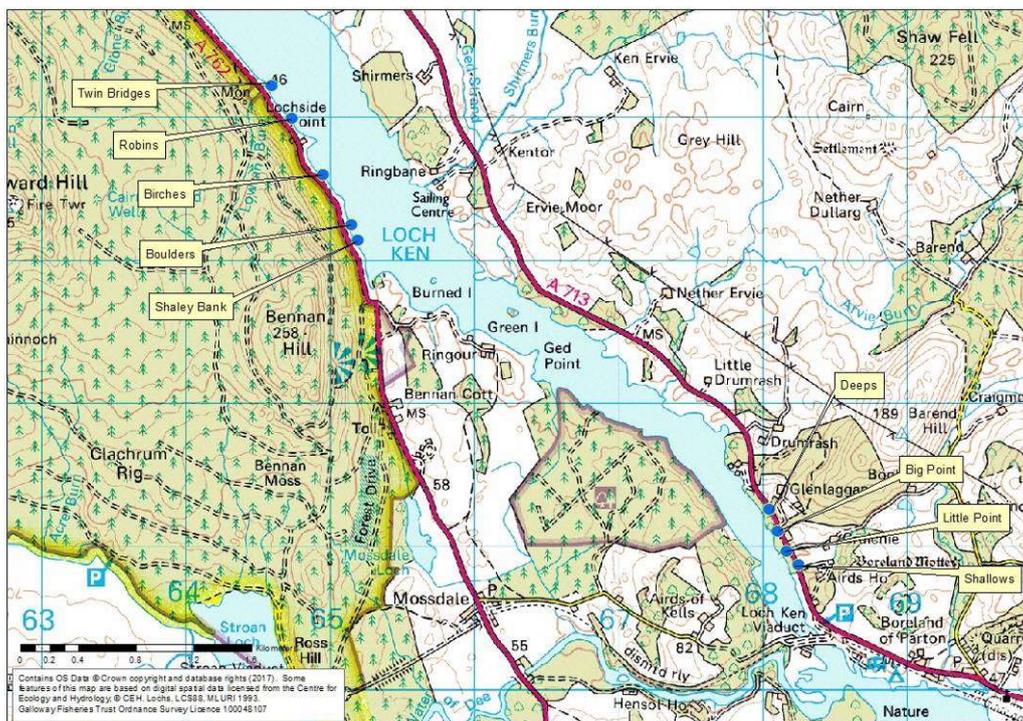
2. METHODOLOGY

2.1 Monitoring Loch Ken Coarse fish stocks

2.1.1 Angling matches

Throughout the year and particularly during spring and autumn, a series of large coarse fish matches are held on the west bank within the New Galloway Angling Association (NGAA) water and on the east bank at Glenlaggan. These locations and the given section names can be seen in Map 2 below. When fully subscribed to, these matches can hold up to 45 anglers.

It was recommended within the Galloway Glens Project 'Fish, fisheries and angler survey of Loch Ken' report (2017) that monitoring of coarse fish stocks within Loch Ken should be undertaken annually, through sampling at two angling matches (during spring and autumn), following the protocol developed in the original study and described in Annex 1 of this report.



Map 2: Location map of sections fished during Loch Ken matches

In order to maximise the number of fish available for processing and to begin to enable the first annual comparison in coarse fish data sampled during a match; a match was selected at the end of March 2019. This match corresponded to Match 2 sampled in 2017. Anglers attending this match fished for six hours before weighing their catch/bag and passing its contents over to GFT to process for species, lengths and weights. The 2017 and 2019 matches were organised by the same match organiser. To assess the age structure of the coarse fish communities of Loch Ken, scale samples were collected during fish sampling at the coarse fish match and a proportion were sent to the EA for analysis.

This report discusses the findings from the coarse fish match sampled by the GFT in spring 2019 in relation to the match sampled in March 2017.

2.1.2 Pike and perch sampling

A further section, called the 'Shallows', positioned north of the Twin Bridges on the west bank is the location where most NGAA day ticket holders can fish on match days and where small pike competitions are normally held. Within the Galloway Glens Project '*Fish, fisheries and angler survey in Loch Ken*' report (2017), it was recognised that pike and perch data was limited within the GFT sampling and citizen science data collection methods used in the 2017 study. Within the current study, with the aid of SEPA funding, GFT purchased equipment to create sampling packs that could be distributed to a small number of anglers who target pike and perch from bank and boat fishing on Loch Ken. Each angler would be trained by GFT in how to process length, weight and scale data from pike and perch, to allow them to carry out sampling unassisted by the GFT. Each sampling pack would contain the same set of measuring tools in order to standardise sampling effort by the anglers. The equipment purchased included:

- 10 Angler packs (each containing a dehooking mat, fish weighing scales, fish scale bag and a set of forceps)
- 5 stink bags (for carrying wet keepnets)
- 10 pike tubes
- 10 keep nets
- 3 landing nets
- 10 weighing scales
- 2 measuring/unhooking mats
- 10 weather writers

GFT attended a small pike match held on the 'Shallows' section of the NGAA water along the north west side of Loch Ken. At this match, GFT tested which pieces of equipment would be of most use to the anglers and completed sampling demonstrations on two pike. The anglers fishing this match were left with two sets of equipment to carry out their own sampling of any pike caught within the following two days that the match would span and thereafter, on return visits to the loch during spring 2019.

It became apparent from the original study that large perch were most likely to be sampled by boat anglers on the loch. In order to maximise perch sampling as well as pike, a selection of anglers that had been keen to support sampling activities within the 2017 study, were approached and asked if they could assist in fish sampling as part of the present study. Six anglers responded, three of which were given sampling packs. All anglers were asked to arrange a training event with the GFT at the earliest opportunity when they would be fishing upon the loch. Those of whom did not have a sampling pack, would be given one during a training event. Fish data gathered by this means will be reported within a further report, to be completed once a second coarse fish match has been sampled during autumn 2019.

2.1.3 Condition factor

Measurements from all fish that were sampled for length and weight data at the two matches (150 fish in 2017 and 405 fish in 2019) and during the pike competitions, were used to calculate the condition factor or health of each individual fish as a basis for comparison between species and within species caught at different times of year. Generally, fish that are heavier than the standard weight for their length are considered healthier, having more energy reserves for normal activities, growth and reproduction. Whilst this is a useful metric and indicator of fish health it should be noted that it can be highly variable for example across seasons and dependent on feeding habits of the species being assessed.

The standard Fulton Condition Factor formula was used on this occasion. This formula assumes that the standard weight of a fish is proportional to the cube of its length:

$$K = 100(\text{Weight}/\text{Length})^3$$

where weight is the whole body weight of the fish in grams and length is the fork length of the fish in centimetres. The factor 100 is used to bring K close to a value of one. Fish with a condition factor of greater than one are considered to be in better condition than those fish with condition factors less than one.

2.1.4 Age analysis

Scale samples gathered at the matches were sent to the EA for analysis. By collecting scales and lengths of individual fish from across the different species it was possible to graph the growth rates of each fish species. This is a useful data set to monitor the health of the Loch Ken fishery. It is possible to compare the fish growth rates in Loch Ken against other standard growth rates from across a range of waters. The comparable data is mostly available from England due to the greater levels of research and coarse fish data collection compared to Scotland.

3. RESULTS

3.1 Angling matches

3.1.1 Pike match and training event attended on 22 March 2019

On the 22 March, GFT attended a pike fishing competition being held upon the 'Shallows' on the north west bank of Loch Ken. Six anglers who attended this match were trained in the use of the sampling equipment once the first pike had been landed. *Figure 1* shows a pike that was landed during the competition resting on the unhooking mat before processing. Using the roll-out measure board, fish scales and weighing bag; a measurement of length (cm) and weight (lb/oz) were taken from the fish. Using a pen knife and scale packet, a scale sample was taken and stored for further analysis on age structure (see *Graph 28*). As soon as the processing was complete, the pike was supported in the loch as long as it took to recover, before it was safely released. Having completed a processing demonstration on two pike, a set of sampling equipment was left with the competition anglers, to allow for further sampling of pike to be undertaken during the rest of their three day match and during future fishing events on the loch.



Figure 1: A pike during sampling efforts on the 22 March

The anglers fished a further two days on the loch and in total, eight pike were sampled. Pike sampling was undertaken by the same group of anglers on one further occasion, in May 2019, when a further two pike were caught. Details of the information collected by the pike anglers can be seen in Table 1.

Table 1: Pike data obtained during pike competitions on Loch Ken

Record No.	Date	Fish Species	Length (cm)	Weight (lb/oz)	Comments
1	22/03/2019	Pike	69	6 lb 11 oz	Tear on flank. Female.
2	22/03/2019	Pike	61	5 lb	Female. Good condition.
3	22/03/2019	Pike	88	9 lb 3 oz	Female. Few scrapes around tail.
4	23/03/2019	Pike	63	4 lb	Female. Good condition.
5	24/03/2019	Pike	86	12 lb 7 oz	Very good condition.

6	24/03/2019	Pike	99	18.82 lb	Female. Very good condition.
7	24/03/2019	Pike	81	9.9 lb	Female. Very good condition.
8	24/03/2019	Pike	NR*	9.24 lb	
9	04/05/2019	Pike	NR*	7.5 lb	Good condition
10	04/05/2019	Pike	NR*	4.9 lb	Good condition
			NR*	=	Not recorded

Scale samples were processed for age data. This data is discussed in Section 3.3.

3.1.2 Loch Ken coarse fish match attended on 30 March 2019

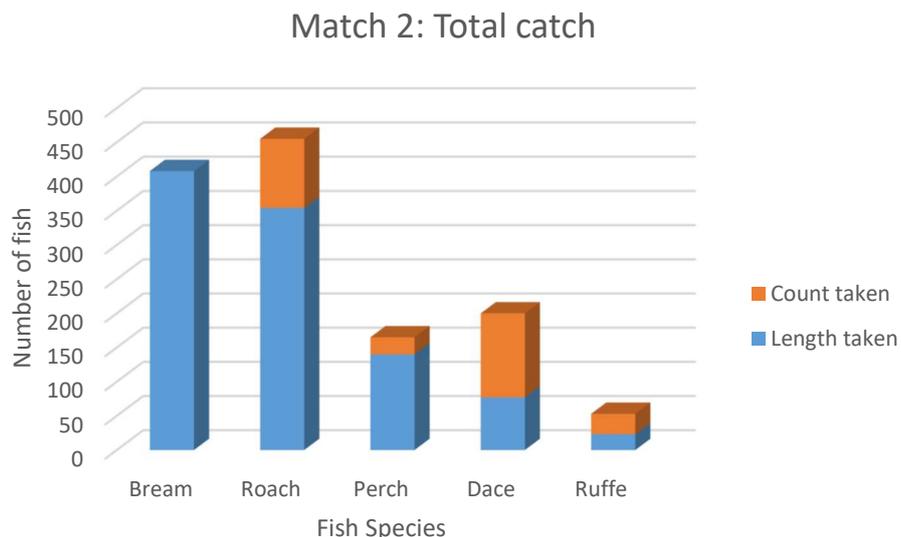
On the 30 March 2019, GFT attended a large coarse fish match on Loch Ken when 45 anglers competed. All available sections, as shown in Map 2, (*Section 2.1.1*) were fished. Five anglers did not submit their catches for weigh in. A total of 1281 fish were available for sampling from 18:00 hrs. GFT completed processing this sample beyond midnight.

In total, 1002 length measurements were taken from 408 bream, 354 roach, 140 perch, 77 dace and 23 ruffe. In addition, weights were obtained from 405 of these fish (232 bream, 53 roach, 20 dace, 90 perch and 10 ruffe).

To further understanding of age structure of coarse fish in Loch Ken, scale samples were taken from 76 fish (35 bream, 22 roach, 12 dace and 7 perch). Scale samples were not taken from ruffe (see Annex 1).

A further 279 fish had species only recorded bringing the total number of fish sampled during this match to 1281.

Graph 1 shows the distribution of fish available for processing from this match, with those shown in blue all fish where species length and a proportion of weight was recorded and scale samples taken. The proportion of the sample where a species count only was made is shown in orange.

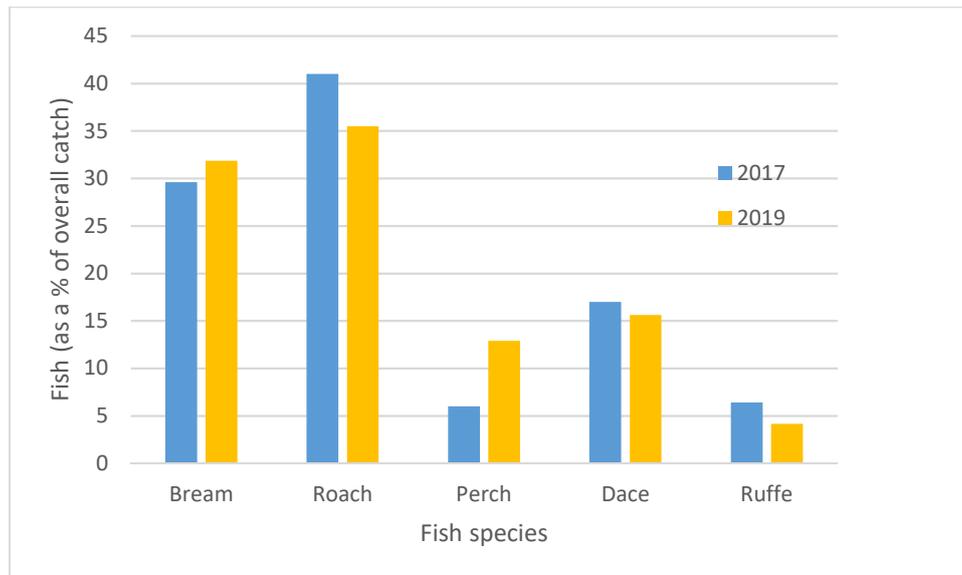


Graph 1: Total fish captured in the match (2019) shown as number of fish where length (and a proportion of weight and scale) sampling was completed and numbers of fish where only a count of individuals was taken

3.1.3 Match catch data between years

3.1.3.1 Species mix as a proportion of total sample

Twenty anglers provided a total of 827 coarse fish samples in the match attended by GFT in March 2017. Because the corresponding match attended this year had a greater fishing effort (45 anglers) and therefore total fish sample; a direct relation between the individual species mix from the two matches has been presented as a proportion of the total match sample. Graph 2 shows the comparison in total individual fish species caught between the two year's matches.



Graph 2: Individual fish species as a percent of total match catch

From the match sampled in March 2017, it can be seen that roach made up the majority of catches (>35% of the sample). In 2019, roach were also the dominant catch (41% of the sample). Bream were recorded in similar proportion between the two years (~30% in 2017 and >31% in 2019). Dace were the third most common fish species recorded both years, making up 17% of the total catch in 2017 and >15% of the total catch in 2019. Perch catches varied most between the two years with 165 being recorded in 2019 (~13% of the total catch) and only 50 in 2017 (6% of the total catch). Exactly 53 ruffe were sampled at both matches (making up the least proportion of fish caught during the 2017 and 2019 March matches sampled).

3.1.3.2 Individual pegs and section bag weights recorded at the match (2017 and 2019)

For future comparison with current data, the total bag weights of fish caught at each peg during the two matches compared in this study are shown in Table 2 below.

Table 2: Bag weights of coarse fish captured upon individual Loch Ken angling pegs during the match attended in this study and the corresponding match of 2017

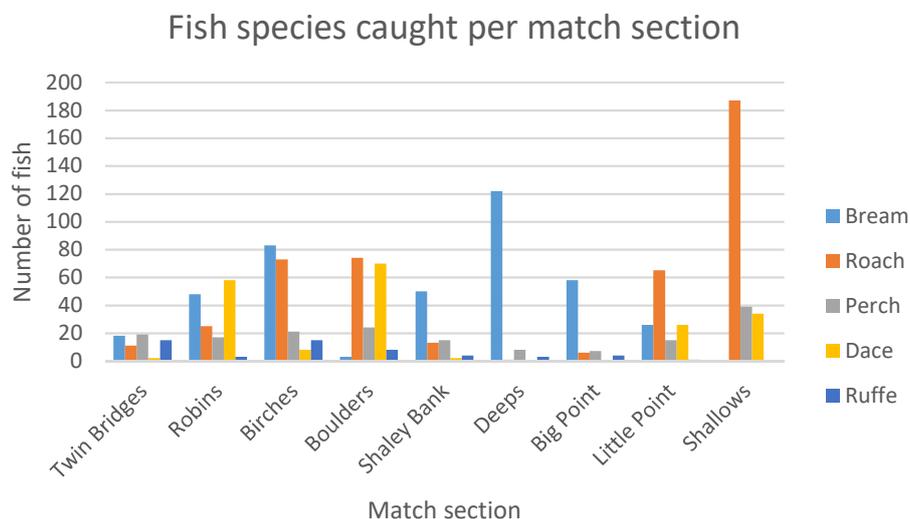
Section	Angler #	Bag weight (lb/oz)	Bag weight (lb/oz)	Total section weight (lb/oz)	Total section weight (lb/oz)	Average bag weight (lb/oz)	
Name		2019	2017	2019	2017	2019	2017
West Bank							
Twin Bridges	1	DNW	N/A	17.5 lb	N/A	>5.8 lb	
	2	8 lb 8 oz					
	3	4 lb 8 oz					
	4	4 lb 8 oz					
Robins	5	6 lb	0 lb 1 oz	44 lb	19.9 lb	>7.3 lb	>4.9 lb
	6	7 lb	2 lb 12 oz				
	7	7 lb 4 oz	14 lb 12 oz				
	8	5 lb 8 oz	2 lb 6 oz				
	9	9 lb 4 oz					
	10	9 lb					
Birches	11	7 lb	9 lb 2 oz	65.25 lb	25 lb	>13.05 lb	5 lb
	12	5 lb 14 oz	2 lb 6 oz				
	13	21lb 10 oz	6lb 10 oz				
	14	22 lb 14 oz	3 lb 8 oz				
	15	7 lb 14 oz	3 lb 6 oz				
Boulders	16	3 lb 8 oz	3 lb 14 oz	19.75 lb	24 lb	>3.9 lb	6 lb
	17	3 lb	10 lb 4 oz				
	18	7 lb 10 oz	5 lb 10 oz				
	19	2 lb 14 oz	N/A				
	20	2 lb 12 oz	4 lb 4 oz				
Shaley Bank				28.875 lb	N/A		
	21	13 lb 4 oz	N/A			>9.6 lb	N/A
	22	6 lb 8 oz					
	23	9 lb 2 oz					
	24	DNW					
25	DNW						
East Bank							
Deeps	26	10 lb 12 oz	N/A	54 lb	N/A	9 lb	N/A
	27	11 lb 8 oz					
	28	2 lb 12 oz					
	29	12 lb					
	30	12 lb					
	31	5 lb					
Big Point	32	7 lb	9 lb 10 oz	30.25 lb	16 lb 10 oz	>10 lb	>8.3 lb
	33	9 lb	7 lb				
	34	14 lb 4 oz	N/A				

Little Point	35	DNW	N/A				
	36	7 lb 12 oz	11 lb	25 lb	77 lb 14 oz	6.25 lb	>15.5 lbs
	37	1 lb 8 oz	11 lb 12 oz				
	38	1 lb 8 oz	19 lb 2 oz				
	39	9 lb 4 oz	18 lb				
Shallows	40	DNW	18 lb				
	41	6 lb	8 lb 2 oz	30 lb	37 lb 6 oz	6 lb	>7.4 lbs
	42	6 lb	9 lb 2 oz				
	43	9 lb 4 oz	5 lb 4 oz				
	44	5 lb 12 oz	7 lb				
	45	3 lb	7 lb 14 oz				

On the west bank; of the stretches that were fished on both occasions; the average bag weight recorded on Robins was >7 lb in 2019 and >4 lb in 2017. On Birches, the average bag weight recorded in 2019 was >13 lbs compared to only 5 lb in 2017. On Boulders, 2017 produced a greater average bag weight of 6 lb compared with >3 lb recorded in 2019. Upon the east bank, of the sections that were fished on both occasions; the average bag weights recorded on Big Point and Shallows were fairly similar between years (8.3 – 10 lb on Big Point and 6 – 7.4 lb on Shallows). Little Point produced the greatest difference in catches, with 2017 recording an average bag weight of >15.5 lb compared to only 6.25 lb in 2019.

Individual bag weights are recorded by peg/angler number on each section. However, individual bag contents are not recorded (due to limitations of time and resources). Instead, a total section weight can be calculated and from this, a means of estimating which species are most abundant and how this species contributes to the match result on any given section.

Graph 3 shows the individual fish species mix on each section fished during the 2019 match.



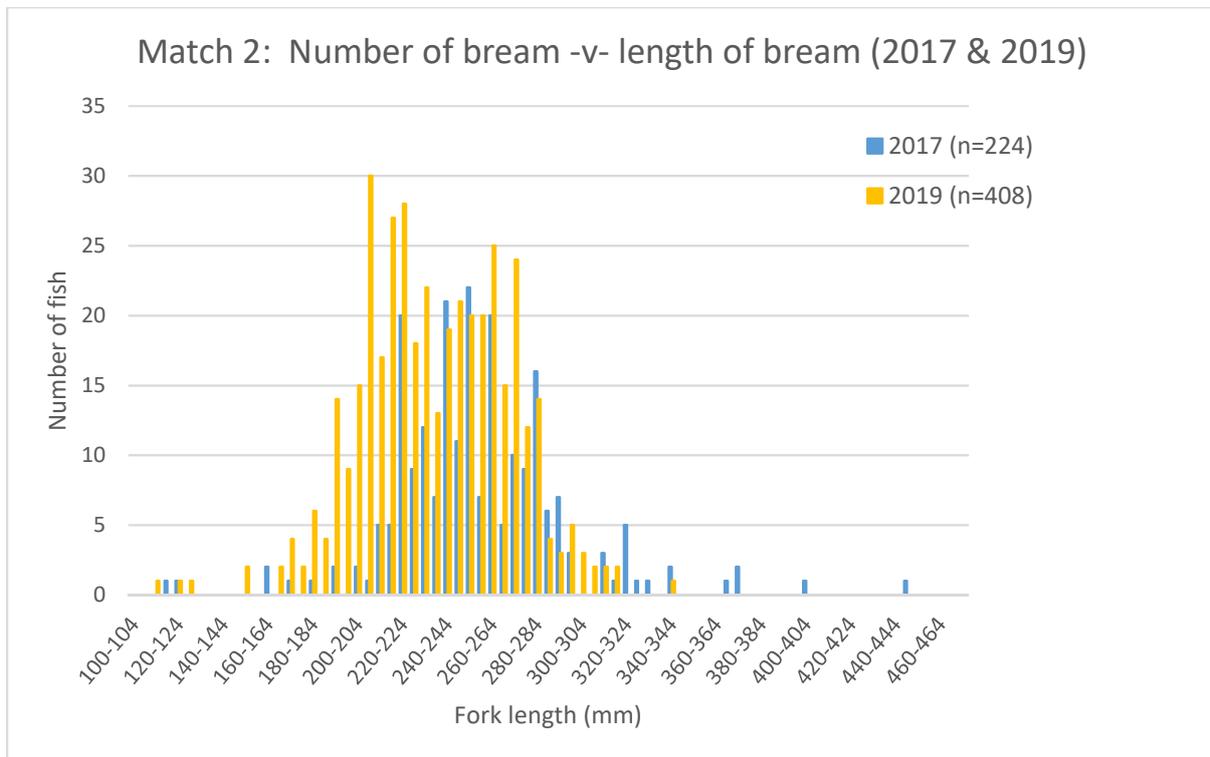
Graph 3: Coarse fish species mix caught on each section during the match (2019)

From the 2019 data provided in Table 2, we can see that the largest total section weight of >65 lb, was recorded on 'Birches' where a similar proportion of bream and roach were recorded. On sections where bream make up the majority of catches (e.g. on 'Deepes'), a large total section weight was recorded (54 lb). In contrast, where bream were absent in the catches, but roach were caught in very large amounts (e.g. on 'Shallows') a good total section weight could still be recorded (30 lb). The number of anglers fishing each section, the

experience of anglers and the method by which they fish, weather conditions, the loch height and at what stage individual fish species are in regards to their migration pattern between deep and shallow sections of the loch and potentially their spawning activity; are among some of the factors which may influence catches made on individual sections. Overall, having an understanding of what fish are caught on each section can give an idea of where individual fish stocks can be utilised in what areas of the loch.

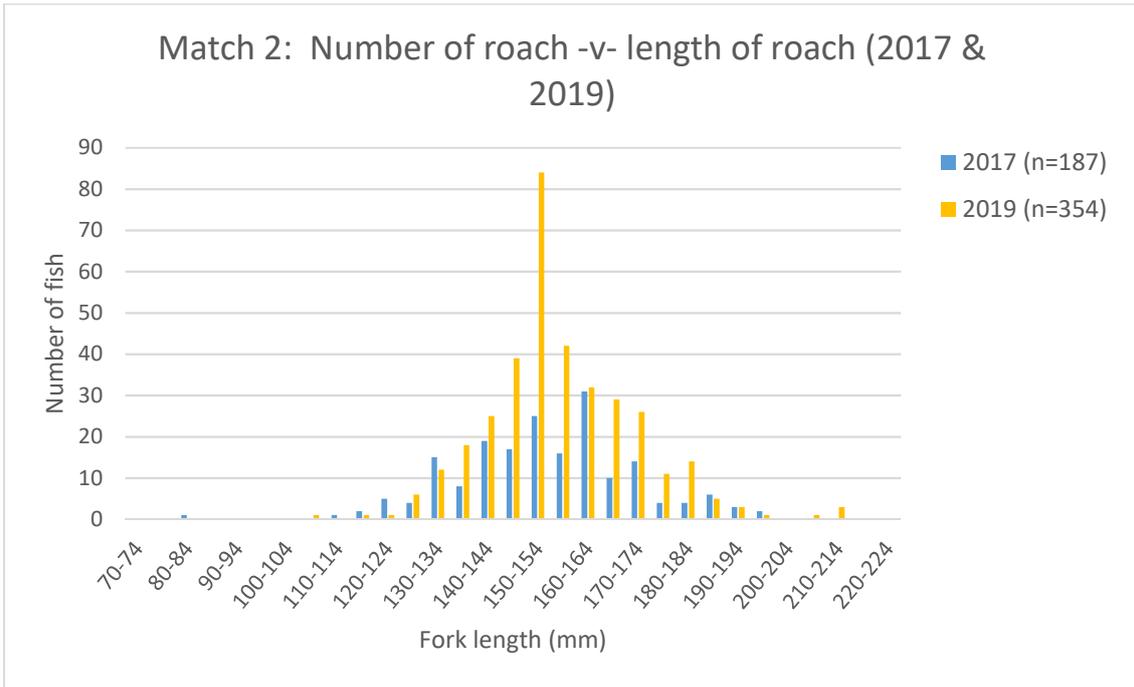
3.1.3.3 Individual fish species length data recorded at the match (2017 and 2019)

The lengths of individual fish species sampled during match 2 (2017) and the present study are shown in Graphs 4 to 8. Length samples ranged by species as follows - bream 11 – 44 cm in 2017 and 11 – 34 in 2019 (*Graph 4*); roach 8 – 20 cm in 2017 and 11 – 21 cm in 2019 (*Graph 5*); perch 9 – 33 cm in 2017 and 10 – 37 cm in 2019 (*Graph 6*); dace 10 - 21 cm in 2017 and 13 – 19 cm in 2019 (*Graph 7*) and ruffe 7 – 11 cm in both years (*Graph 8*).



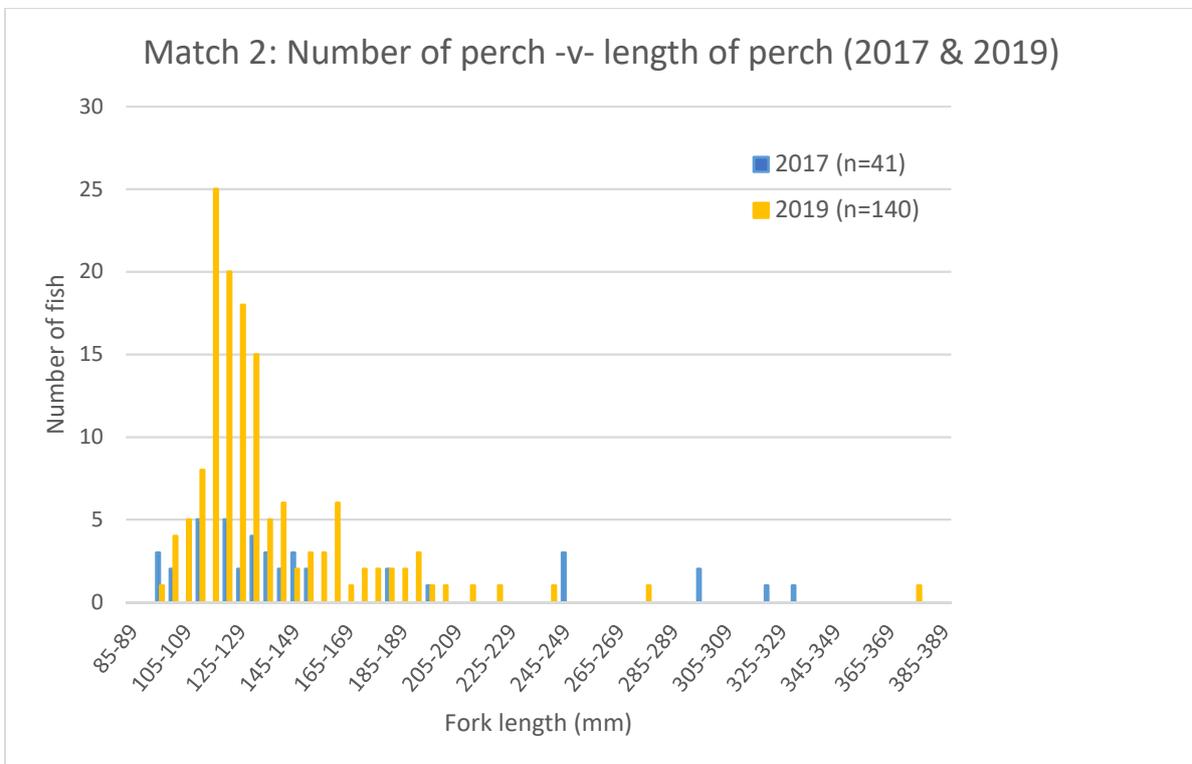
Graph 4: Length histogram of bream sampled during the matches (2017 & 2019)

All bream available in 2019 were sampled for length (408 bream) and only a further 21 bream could have been sampled for length in 2017; therefore *Graph 4* is fairly representative of what was available to anglers at the same time of year across two years. From the graph, it would be fair to say that in general, bream were found to be smaller in 2019 than 2017. There was also a lack of much larger bream, with the maximum size recorded as 34 cm when bream up to 44 cm had been among catches in 2017. Bream hybrids were not noticeable in the 2019 catches. Bream that were likely to be hybrids were not sampled.



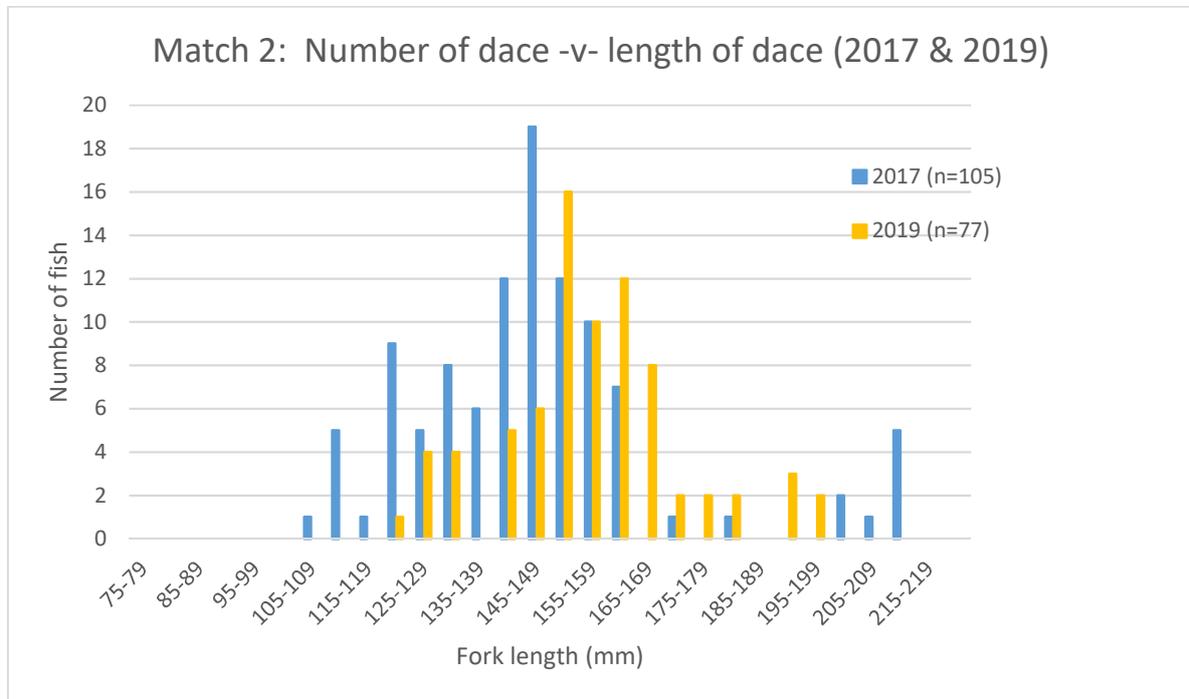
Graph 5: Length histogram of roach sampled during the matches (2017 & 2019)

354 roach from a possible 455 (77% of total catch) were sampled for length in 2019. 187 roach from a possible 338 (55% of total catch) were sampled for length in 2017. The graph shows that roach were most commonly sampled for length at around 14 – 16 cm and that in 2019, the largest roach sampled for length was only one centimetre greater than the largest roach sampled in 2017.



Graph 6: Length histogram of perch sampled during the matches (2017 & 2019)

140 perch from a possible 165 (84% of total catch) were sampled for length in 2019. 38 perch from a possible 50 (76% of total catch) sampled for length in 2017. The graph shows that perch were most commonly sampled at lengths between 11 – 13 cm in 2019 and 12 – 14 cm in 2017. The largest perch sampled for length in 2019 was 4 cm greater than the largest perch sampled in 2017.

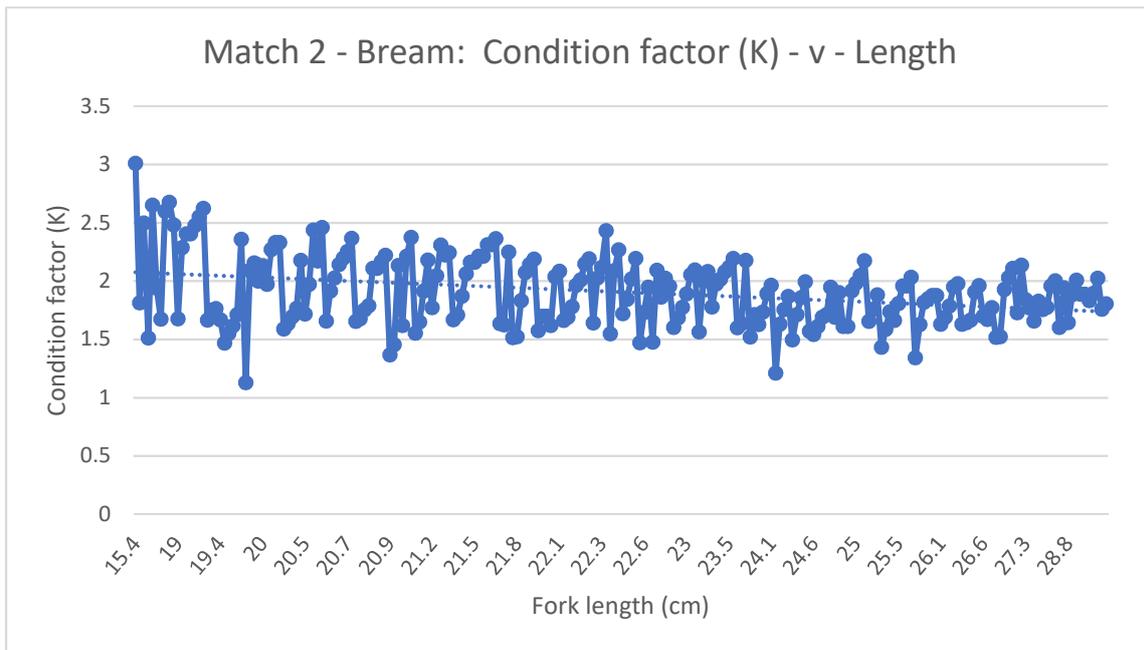


23 ruffe from a possible 53 (43% of total catch) were sampled for length in 2019. 50 ruffe from a possible 53 (94% of total catch) were sampled for length in 2017. The largest and smallest ruffe sampled between the two years were very similar in size.

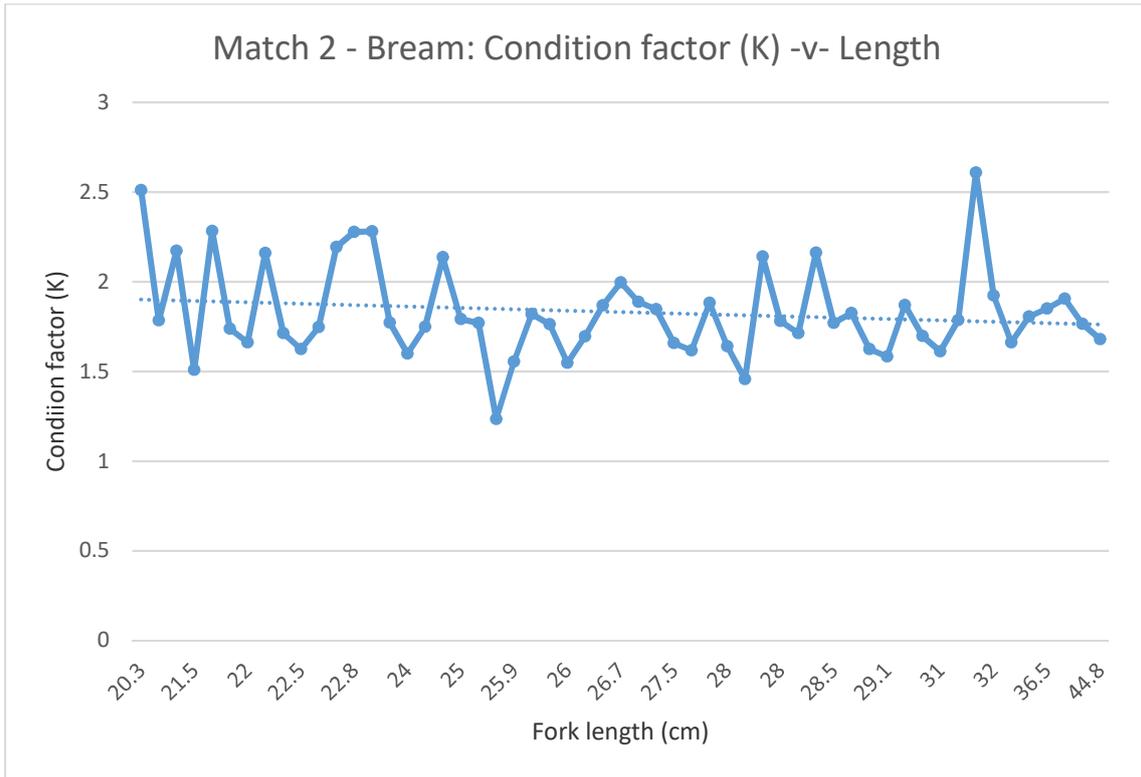
3.2 Condition factor

Length and weight data from each fish species was then used to calculate 'Fulton's Condition Factor'. Individual fish species graphs of condition factor calculated for the 2017 and 2019 matches can be seen in *Graph 9 – Graph 18*.

A line of best fit has been plotted across the range of fork lengths recorded.

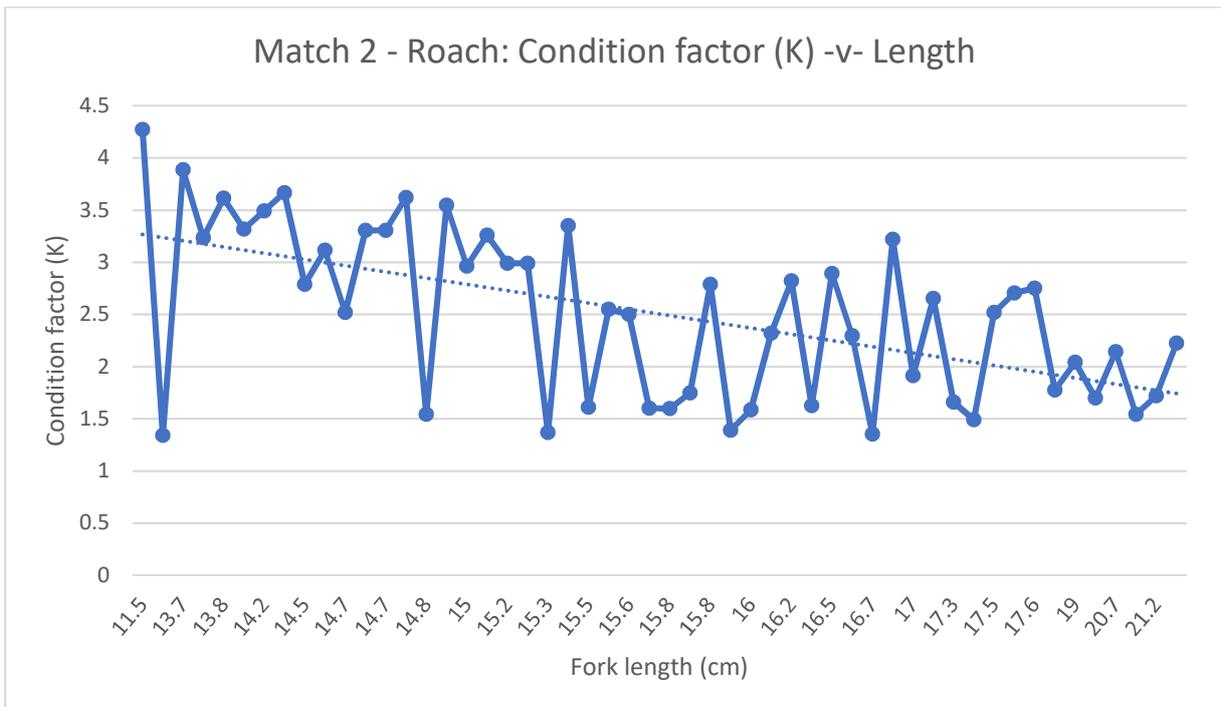


Graph 9: Condition factor of bream sampled during the 2019 match

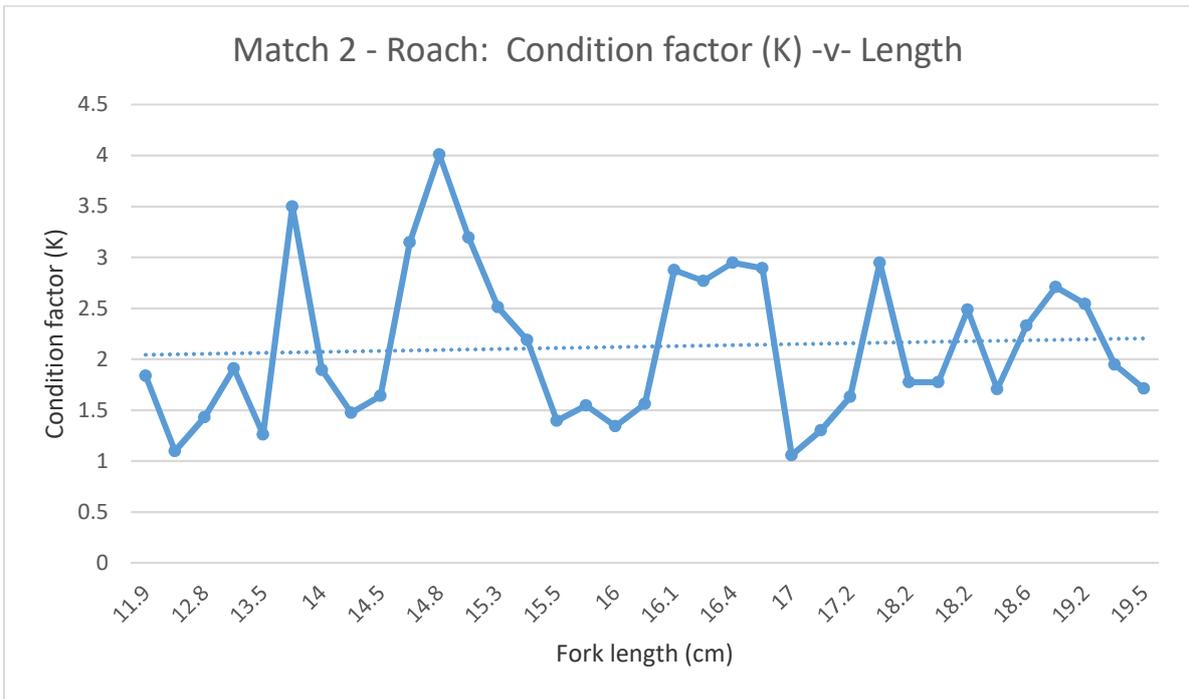


Graph 10: Condition factor of bream sampled during match 2 (2017)

Condition factor of bream was found to be >1 in all fish sampled during both matches. In general, there was a gradual decline in condition factor as bream increased in length across both years.

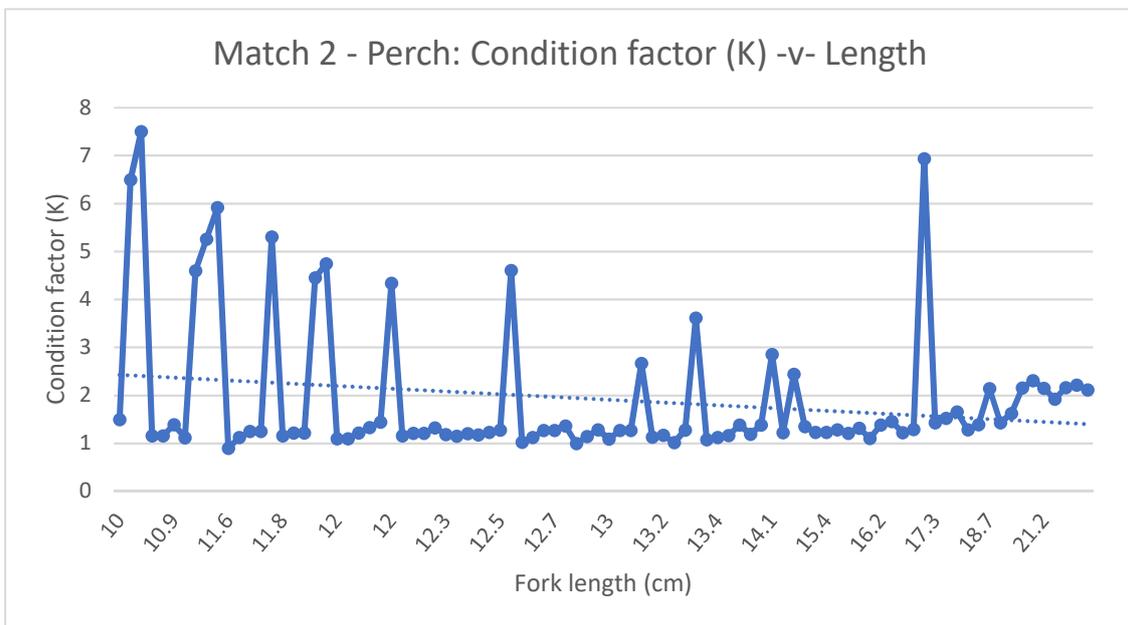


Graph 11: Condition factor of roach sampled during the 2019 match

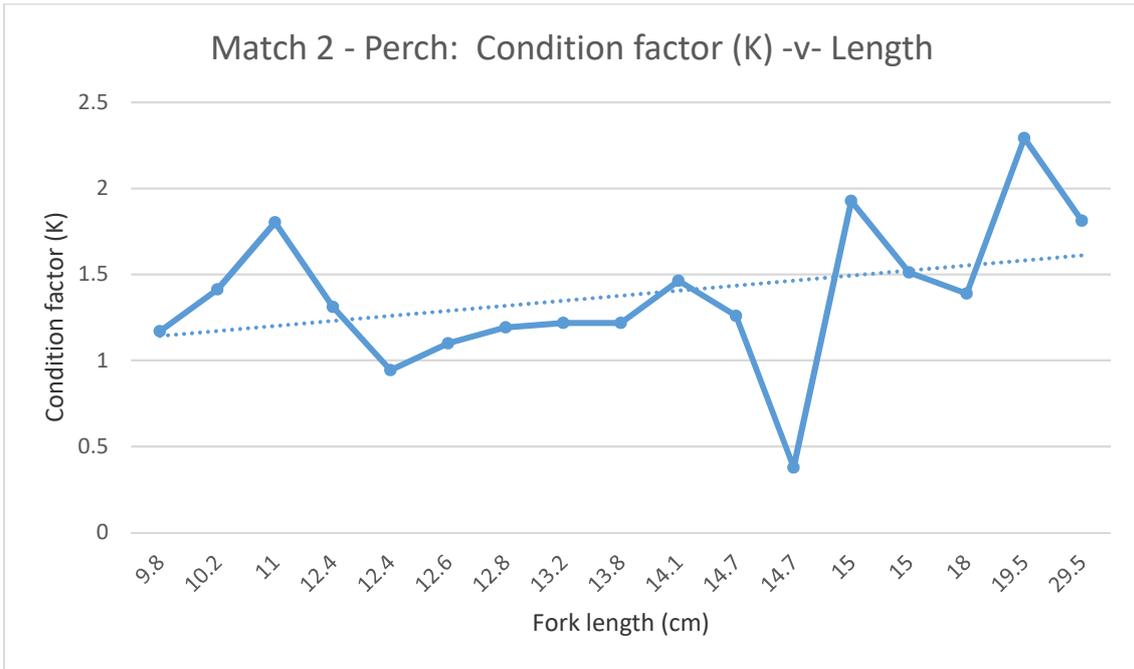


Graph 12: Condition factor of roach sampled during match 2 (2017)

Condition factor of roach was found to be >1 in all fish sampled during the 2019 match and 2017 match. The line of best fit suggests that in 2019, as roach increased in size, their condition factor decreased. In contrast, the 2017 results were relatively stable.

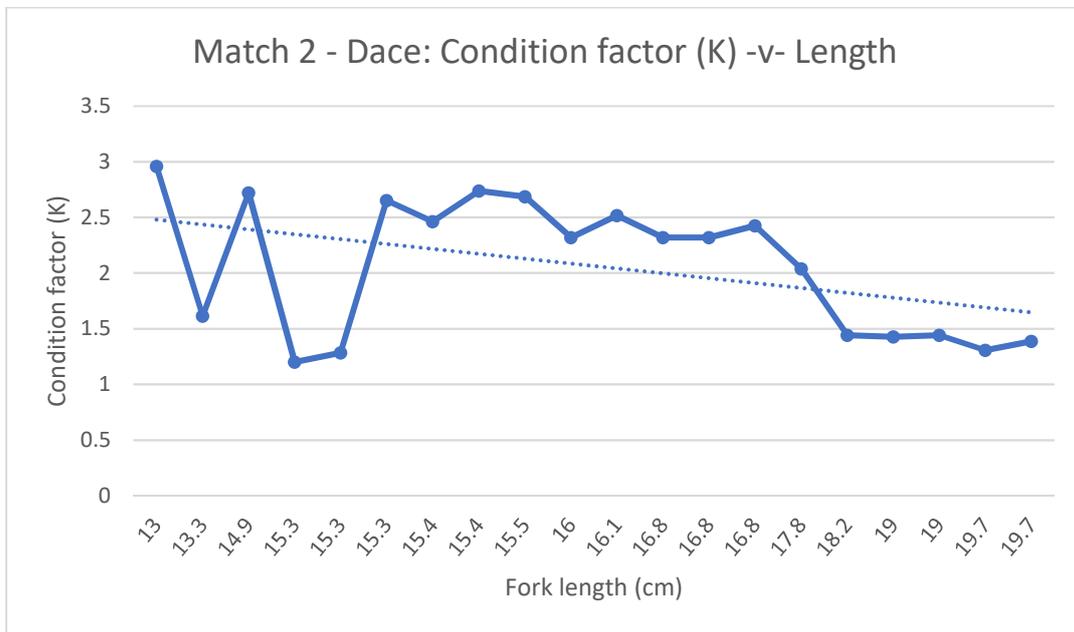


Graph 13: Condition factor of perch sampled during the 2019 match

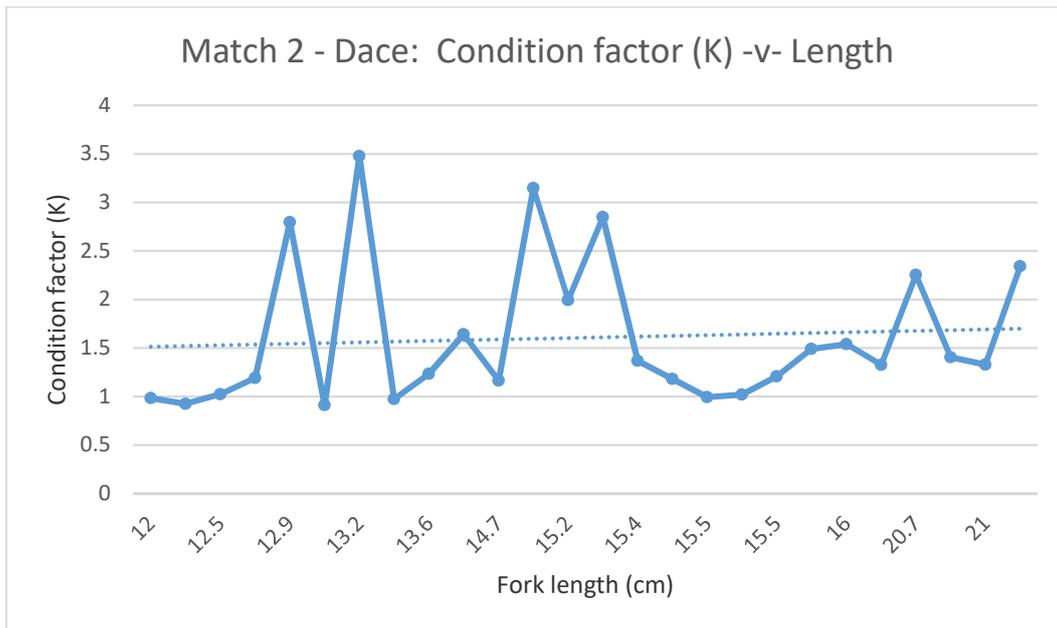


Graph 14: Condition factor of perch sampled during match 2 (2017)

The condition factor for individual perch was much more variable in 2019 than had been suggested in the 2017 sampling, with most showing good health and some specimens, particularly high K factors (to be expected in larger specimens who may be preparing to spawn).

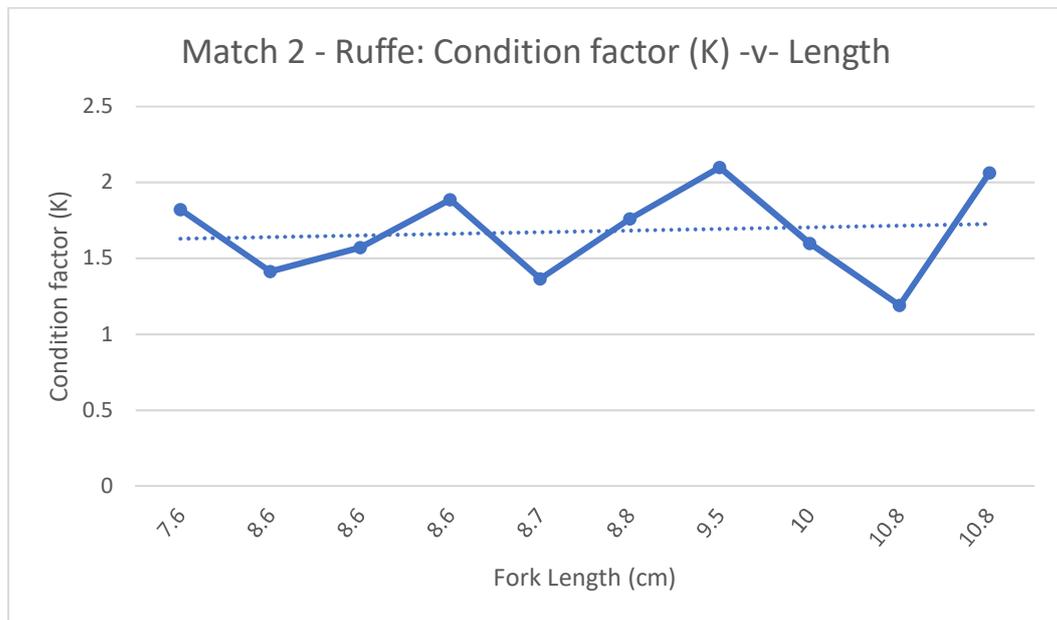


Graph 15: Condition factor of dace sampled during the 2019 match

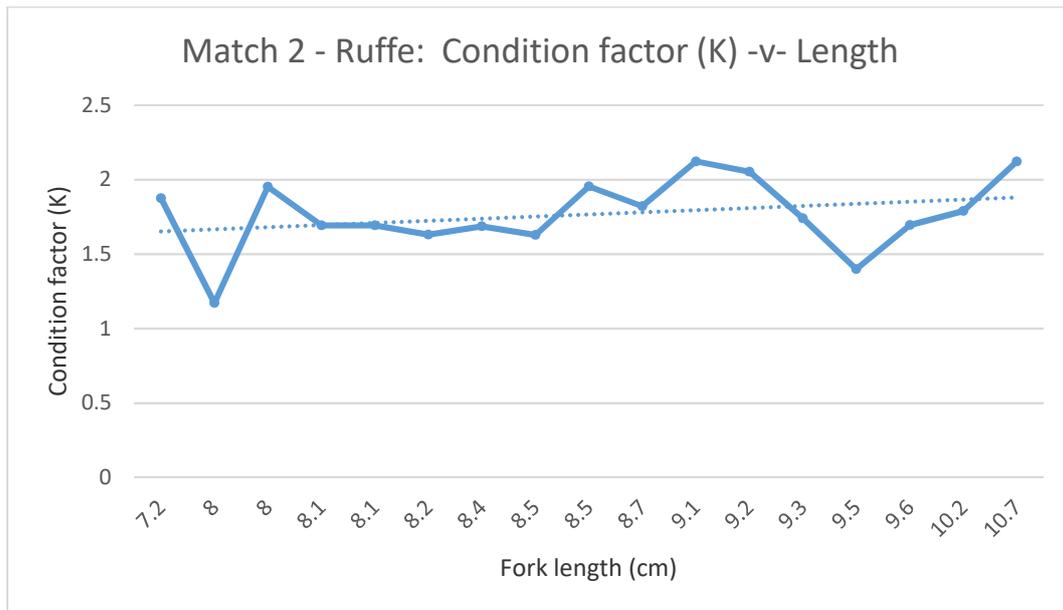


Graph 16: Condition factor of dace sampled during match 2 (2017)

All K values recorded for dace in 2019 were >1, but interestingly, the condition factor for dace appeared to decrease as length of fish increased. Results suggested the opposite trend in 2017 with K values increasing with fish length.



Graph 17: Condition factor of ruffe sampled during the 2019 match



Graph 18: Condition factor of ruffe sampled during match 2 (2017)

The K factor of ruffe remained consistent (>1) between the two sampling events of 2017 and 2019.

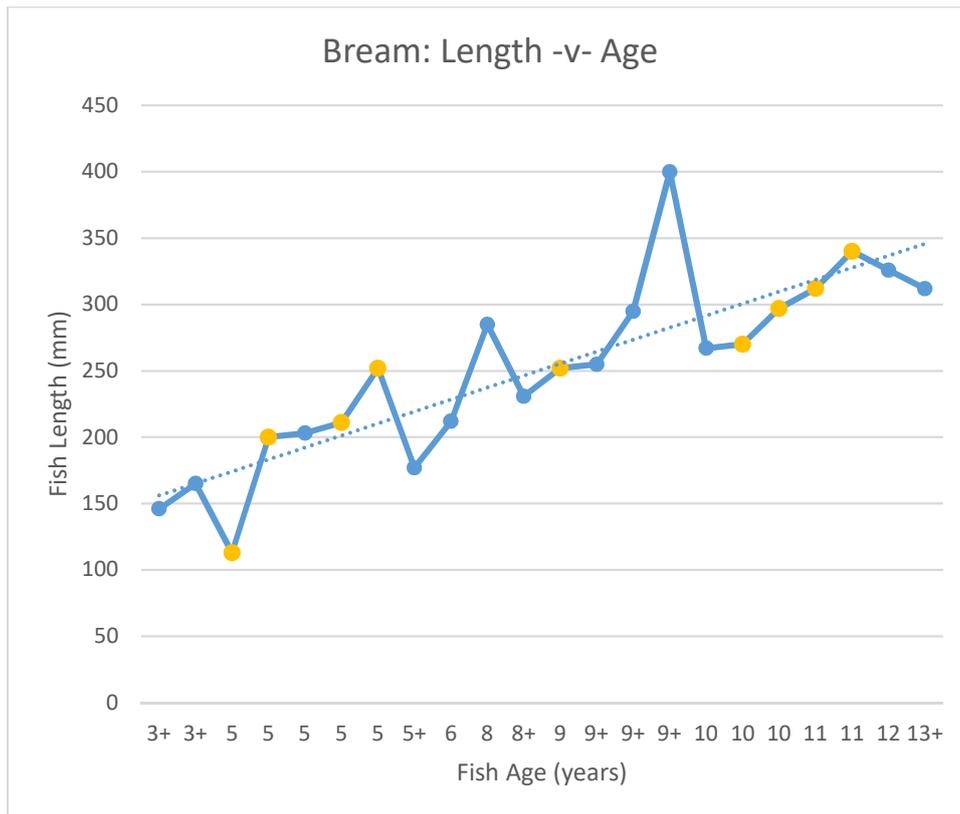
3.3 Fish scale analysis

Having selected scale samples that best represented the variation in individual fish species sizes sampled, 32 scale samples were examined by the EA (they have significant experience in coarse fish scale analysis).

Of the 32 scales submitted, only 26 could be read. When compared to their respective species' standard growth data (National Fisheries Services, unpublished data; Hickley & Sutton, 1984), the perch, roach and pike all had average growth rates, having Percentage Standard Growth (PSG) values of 108%, 106% and 103% respectively. Conversely, the common bream and dace had slow growth rates when compared to their species' standard growth data (Hickley & Dexter, 1979; National Fisheries Services, unpublished data), having PSG values of 78% and 73% respectively. Common bream were aged to 11, roach to 8, pike to 11, and dace to 7 with the maximum age for the perch sampled being three years old. Please note, due to the limited sample sizes for all fish, these data may not be a true representation of the population as a whole.

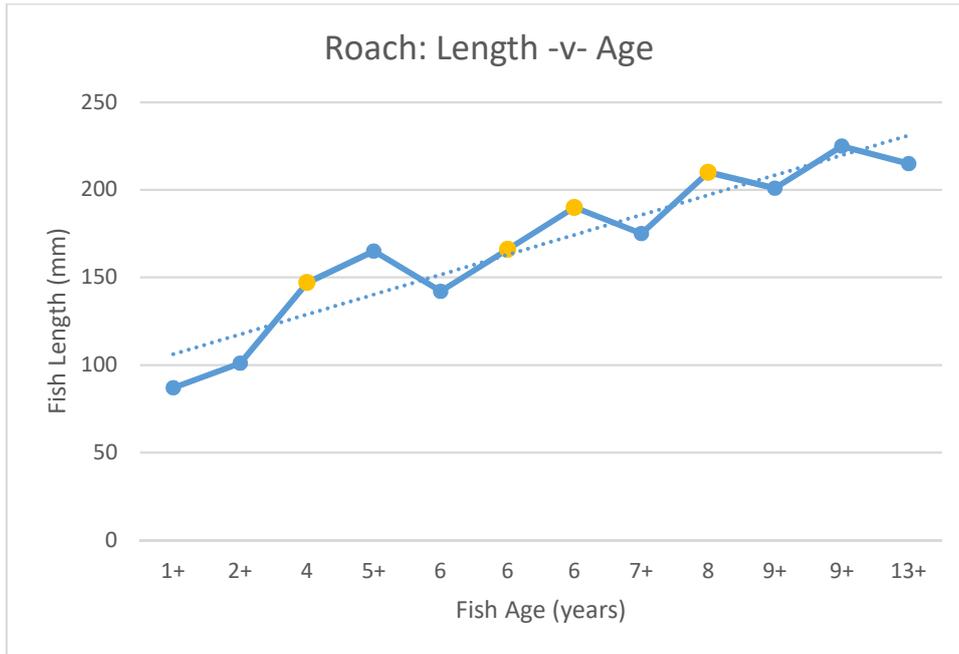
Graphs 19 to 23 show how fish growth changes with age in five coarse fish species commonly caught in Loch Ken in 2017 and 2019*

*all data entries marked in blue are 2017. Data entries marked in yellow are 2019.



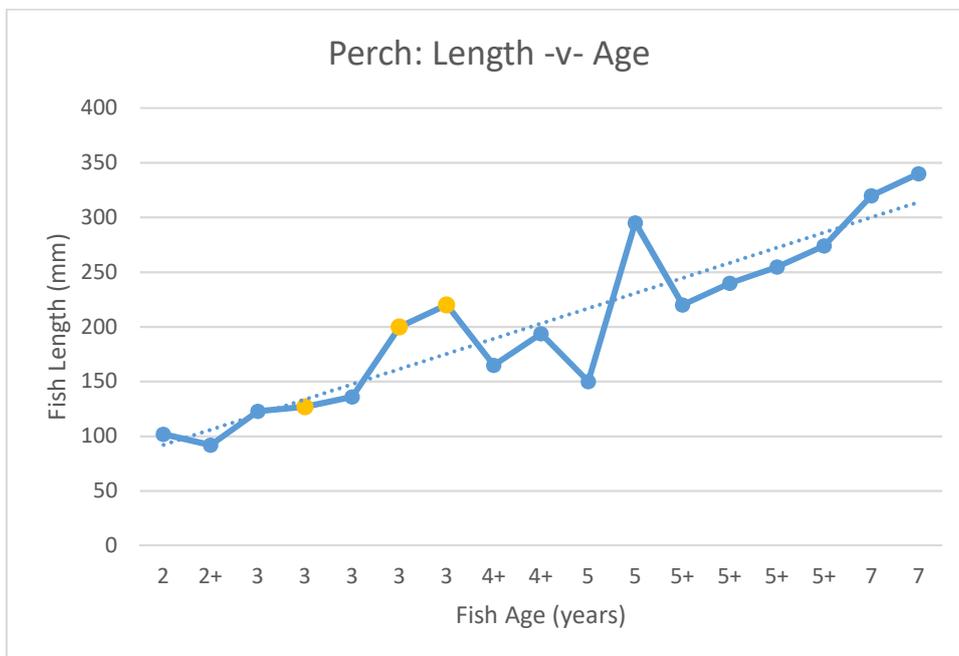
Graph 19: How growth changes with age in bream found within Loch Ken (2017 & 2019)

Growth rates of bream appear to vary widely between years. A slow growth rate was displayed in a single specimen of 113 mm in length, aged as 5 years old in 2019. Analysis of fish age undertaken from 2017 samples would have suggested this fish was most likely less than 3 years old. In contrast, a fast growth rate was shown by a bream of 252 mm in length, which was aged at 5 years old. Within the 2019 data, a bream of 252 mm length was aged as 9 years old – this is in-keeping with analysis undertaken in 2017.



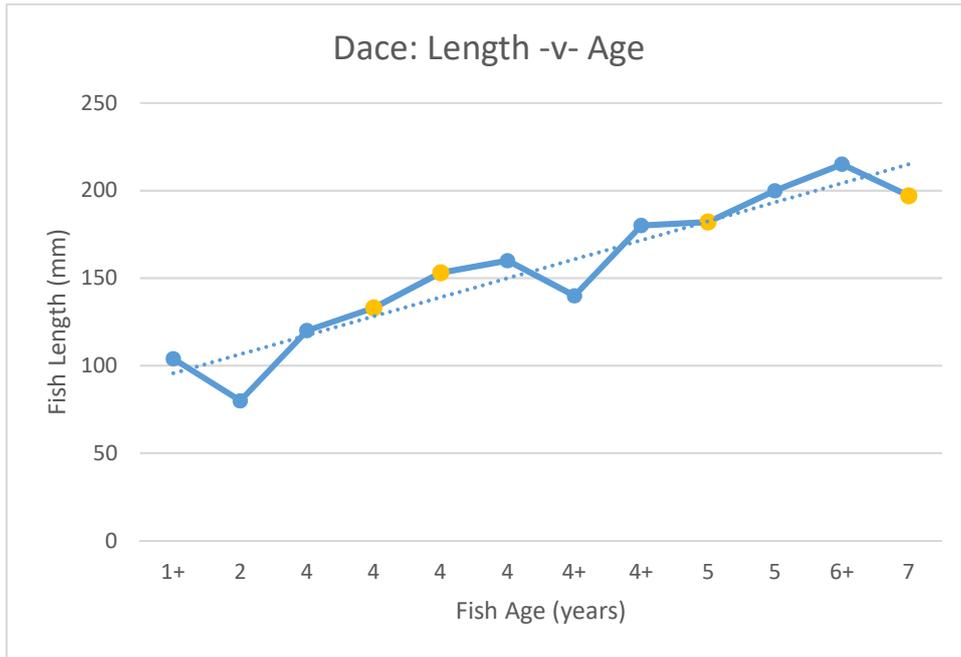
Graph 20: How growth changes with age in roach found within Loch Ken (2017 & 2019)

Within the small sample size (four sets of scale samples) analysed in 2019, an individual roach of 190 mm in length appeared to have a slow growth rate in comparison to a 6 year old roach of 142 mm in length sampled in 2017. Elsewhere, there is variation in maximum fish age sampled between 2017 and 2019; (8 years in 2019 and 13 years in 2017) within only a 5 mm length range. The result of a much slower growth rate displayed in roach sampled this year in comparison to 2017; may be indicative of the very small sample size analysed rather than of the species in general.



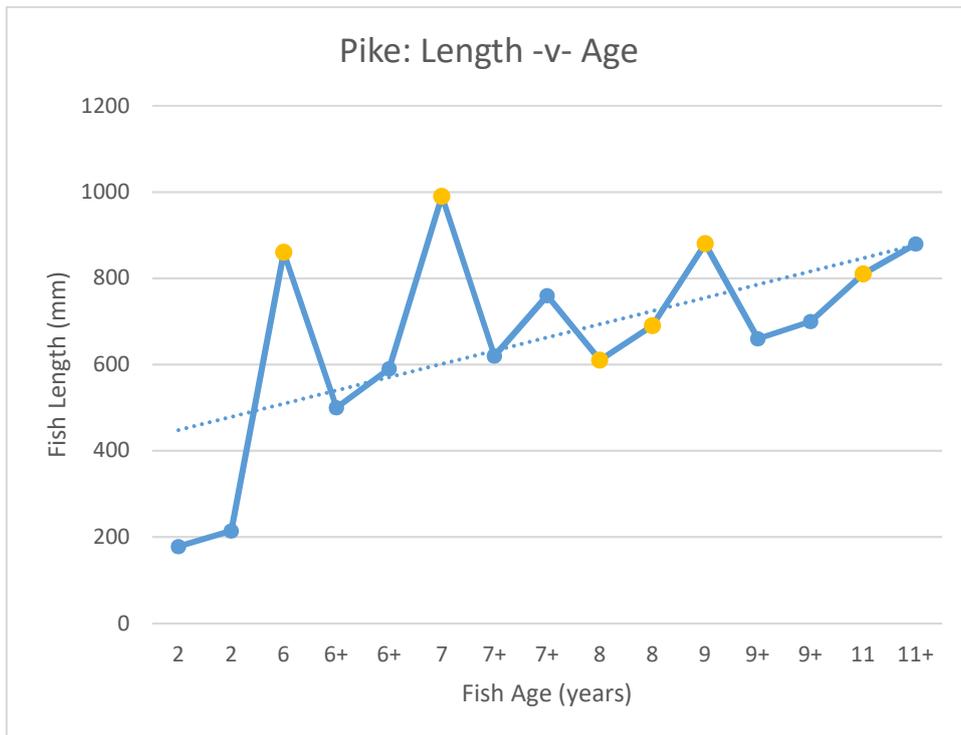
Graph 21: How growth changes with age in perch found within Loch Ken (2017 & 2019)

In 2017, perch were found to have accelerated growth rate from the age of 3 onwards. 2019 data could not support this trend since no perch greater than 3 years old were sampled.



Graph 22: How growth changes with age in dace found within Loch Ken (2017 & 2019)

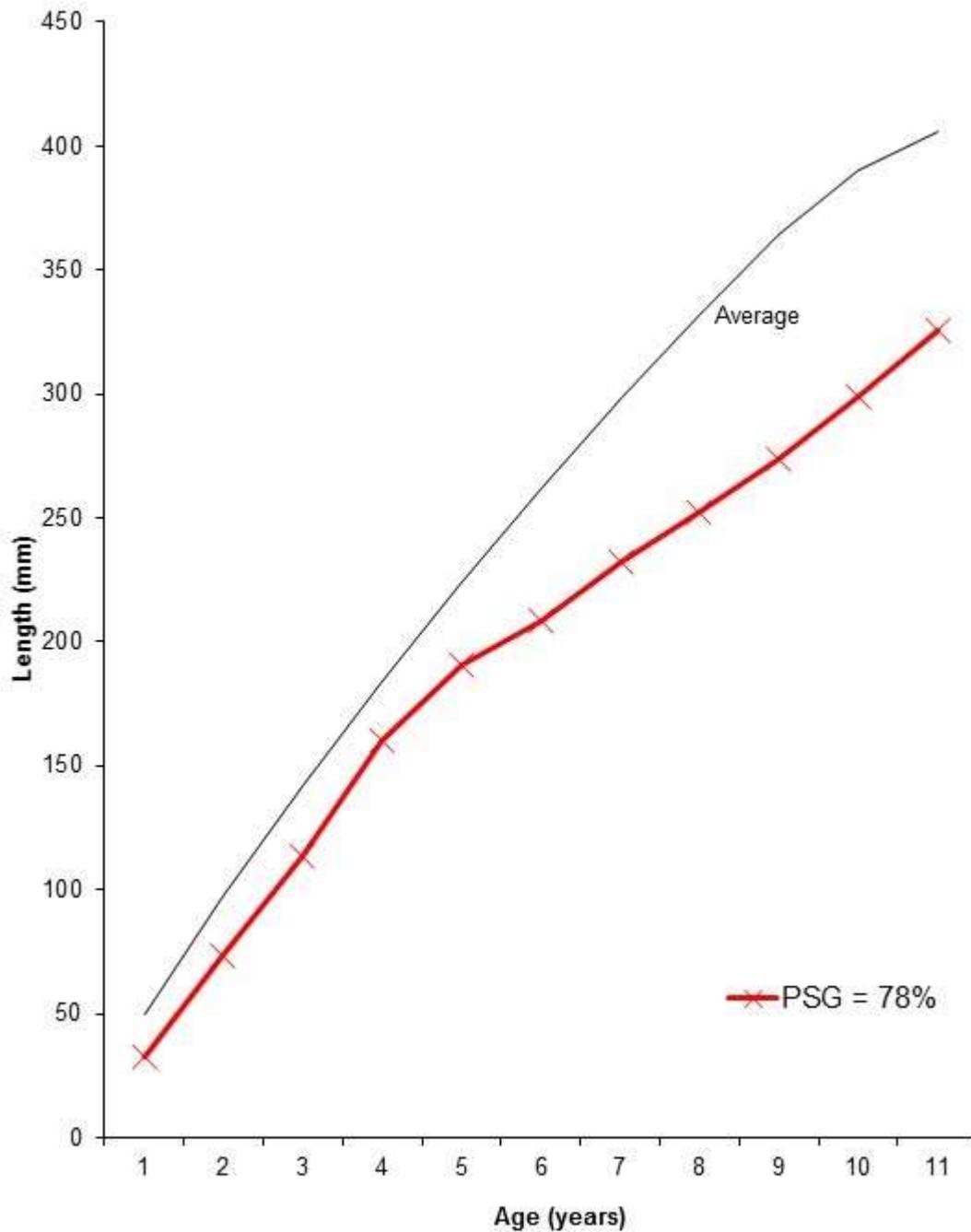
Age analysis of dace showed similar age to length trends to the 2017 data.



Graph 23: How growth changes with age in pike found within Loch Ken (2017 & 2019)

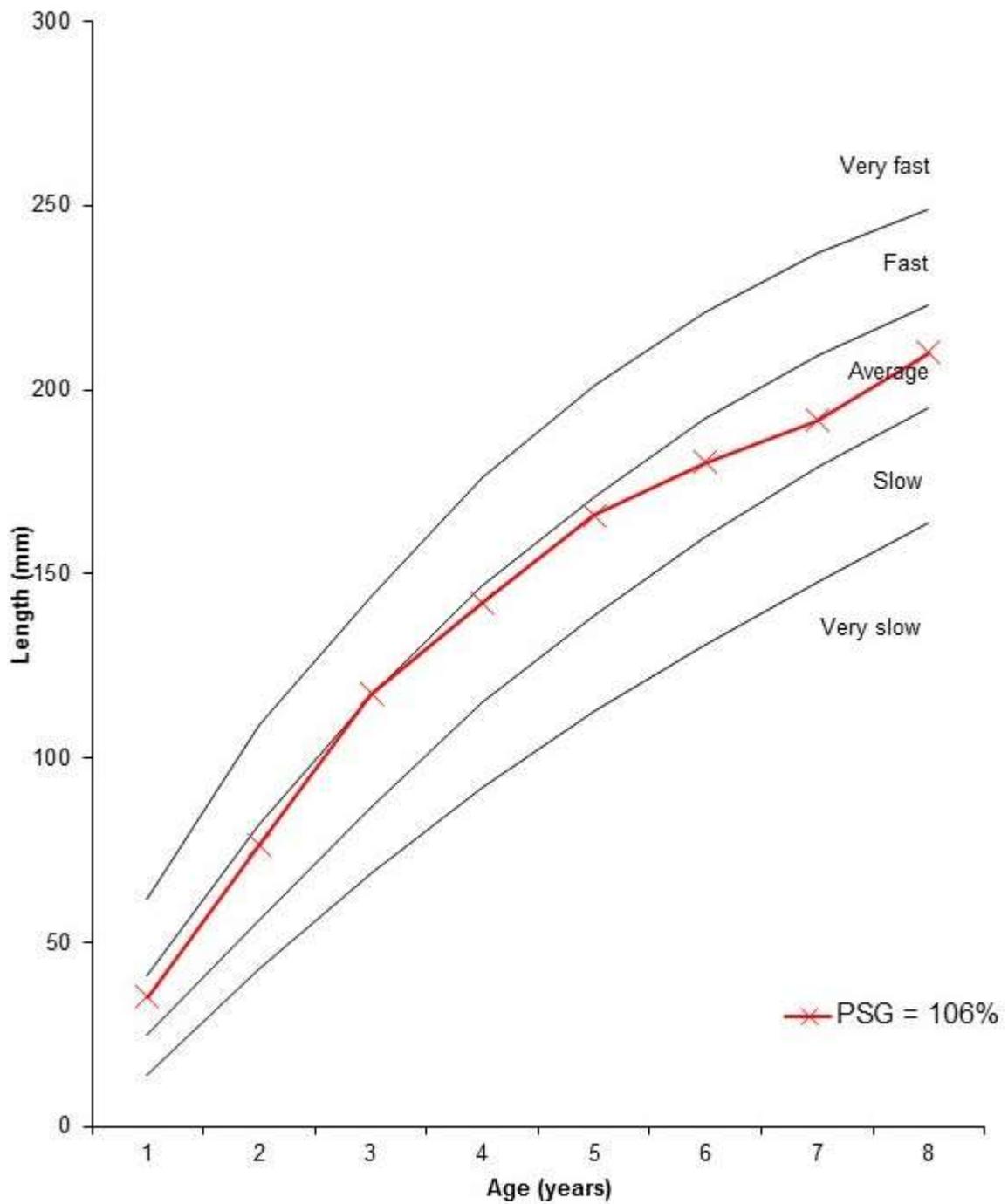
Growth rates in pike are more consistent between the two years of data.

The age data for each fish species is graphed below against 'species standards for Northern English rivers' for roach and dace, and against 'National growth standards' for pike, bream and perch.



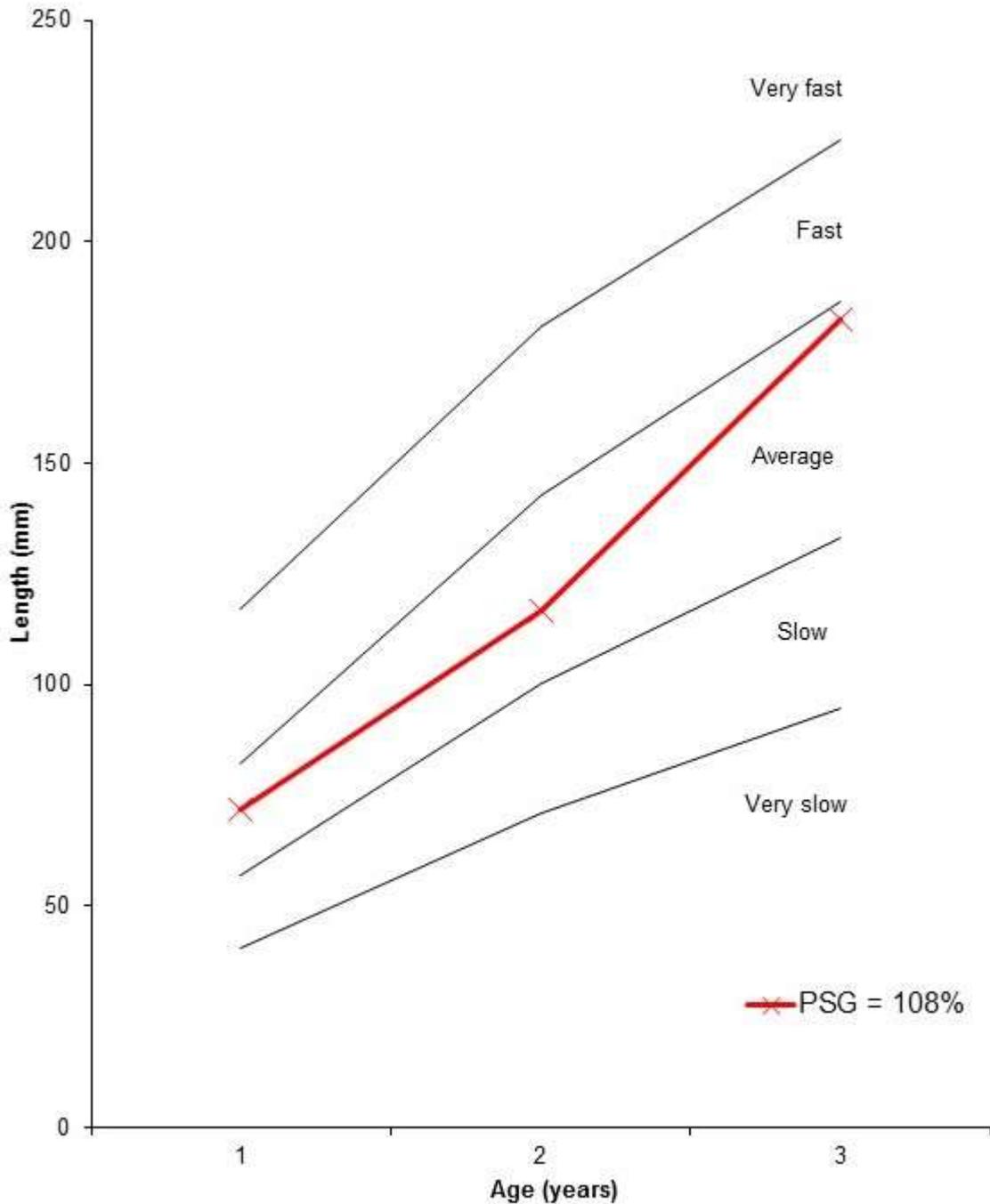
Graph 24: Growth of common bream in Loch Ken compared to the standard growth of common bream in rivers (Hickley and Dexter, 1979)

Common bream showed average growth until about five years old and then growth fell (percentage standard growth (PSG) of 78%) compared to standard growth data from across England (Graph 24). This growth rate is similar to findings from 2017.



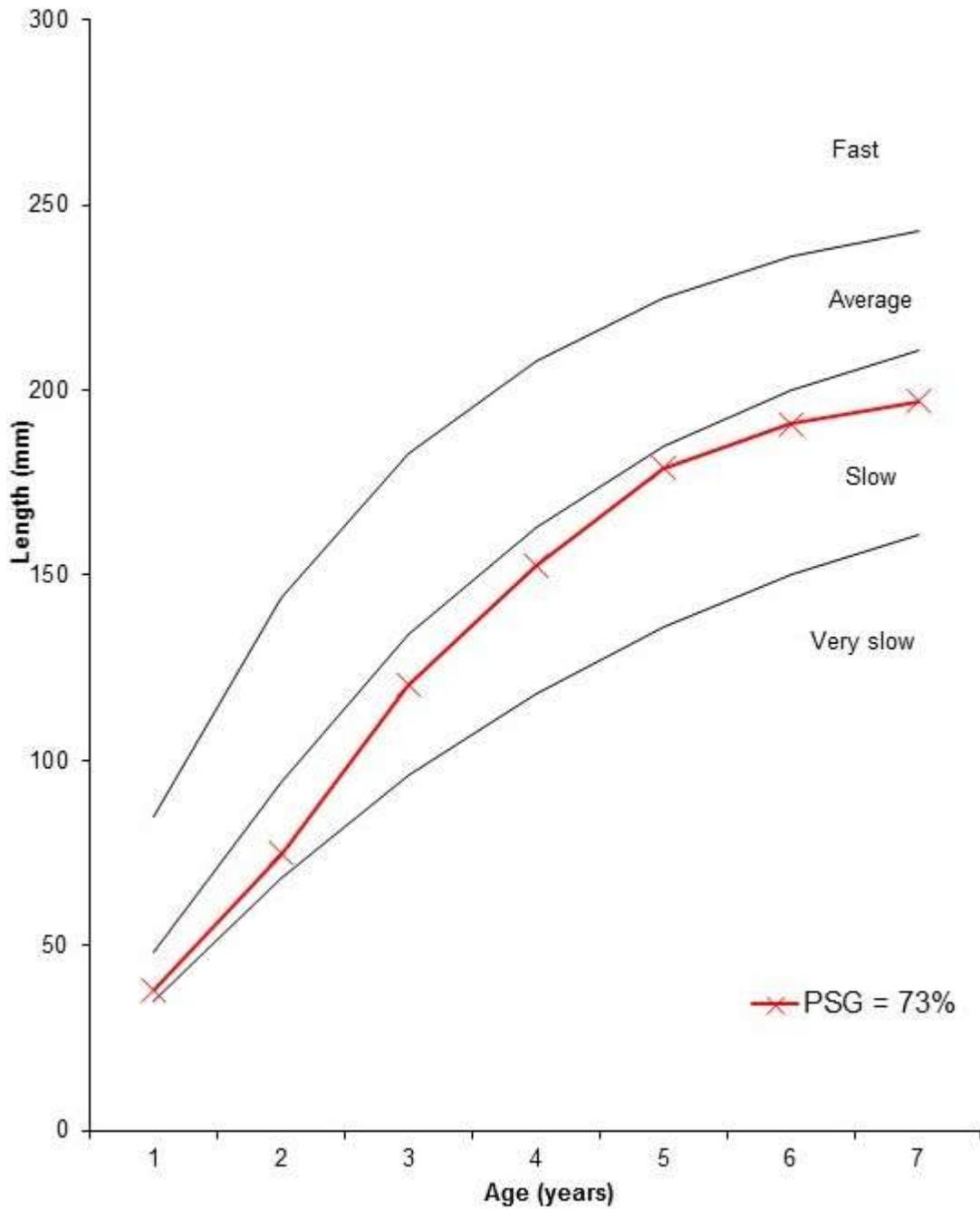
Graph 25: Growth of roach in Loch Ken compared to the standard growth of roach in Northern rivers (National Fisheries Services unpublished data)

The roach were found to have above average growth rates (with a PSG of 106%) when compared to species standards from Northern English rivers (Graph 25). This is an improvement on the 2017 roach growth data.



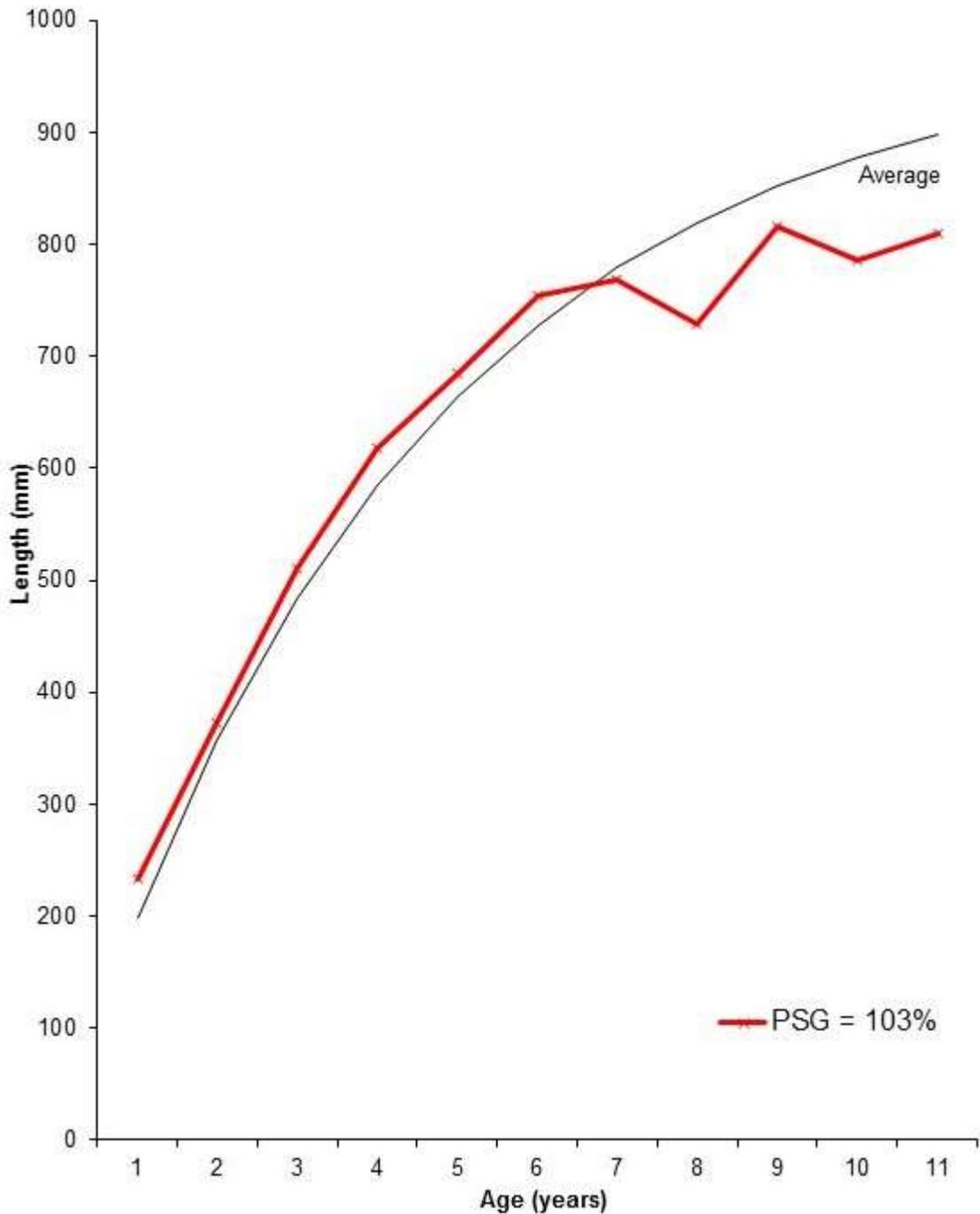
Graph 26: Growth of perch in Loch Ken compared to the standard growth of perch in rivers (National Fisheries Services unpublished data)

The perch from Loch Ken showed normal growth (with a PSG of 108%) when compared to national growth standards (Graph 26). In 2017, perch that were sampled above the age of 4 showed accelerated growth rates. This could not be determined in the present analysis because no perch older than 3 years old could be scale sampled during the match sampling.



Graph 27: Growth of dace in Loch Ken compared to the standard growth of dace in Northern rivers (National Fisheries Services unpublished data)

The dace growth rates were found to be below 'average' (with a PSG of 73%) when compared to species standards from Northern English rivers (Graph 27). Dace sampled in 2017 produced a PSG of 82%, which was close to the average growth rate for dace.



Graph 28: Growth of pike in Loch Ken compared to the standard growth of pike in rivers (Hickley & Sutton, 1984)

Loch Ken pike growth rates (PSG of 103%) when compared to national growth standards from Northern English rivers were average (Graph 28). This is an improvement on the 2017 data (PSG of 68%).

4. DISCUSSION

4.1 Angling matches

The collection of fish data from the catches at angling matches continues to be a successful means of gathering robust data. 1281 fish were sampled at a single match in 2019 and compared to data from the same match of 2017. Species identification of all the fish and the sampling of weights and lengths from a sub-sample was completed. Scale samples were also collected to represent a range of sizes across each of the fish species sampled.

Scale sampling of perch was found to be particularly problematic with no scales being able to be extracted from the largest fish available. In subsequent events where perch are available to sample, a means other than a pen knife, may be required to extract scales. However, fish welfare should not be compromised and if scales are too difficult to obtain, this form of sampling should be discontinued.

Sampling pike during the pike competition was found to be a good means of gathering data. However, in the absence of GFT to assist in samples being taken, some anglers were reluctant to gather fish scale data for fear of damaging the fish. More time may be required to assist anglers especially those fishing from boats, in order that more perch and pike data is collected.

There is significant variance in growth rates within specific age classes and mean growth data should be interpreted with care due to the limited number of fish within each age class. It should also be noted that the growth standards used are calibrated for rivers in England where there is a greater volume of data and study to generate these standards than in Scotland.

4.2 Fish data

Roach are targeted by many anglers particularly during matches where they often make up the largest proportion of the total fish caught (41% of the match catch in 2017 and 35% of the match catch in 2019) and are an important element of the overall fishery. Examination of the condition factor of roach found them to be healthy and growth rates, when considered against EA bandings from England, are fast until the fish are around five years old, after which time growth rate is considered to be average against English data. These findings are an improvement on the 2017 data.

Similarly common bream are an important fish species for the overall fishery (making up >29% of the total match catches in 2017 and >31% in 2019). Bream showed average growth rates, when compared to English standards, until they reached six years old and growth rates fell below the average. This is consistent with the 2017 results.

Loch Ken was known historically as a fishery for large pike with some very large specimen fish reported by anglers. The data sampled during the pike competition in March showed average growth rates, when compared to English standards. This is an improvement on 2017 data.

Loch Ken is recognised for its large specimen perch. Whilst perch were seen to have accelerated growth from three years of age, this year's samples (which were limited to three smaller fish scale samples), could only demonstrate that perch had average growth rates comparable to English standards. In 2017, it was found that perch, from the age of four, demonstrated fast to very fast growth rates in comparison to English standards. Without doing stomach contents analysis on large perch, it is difficult to prove that the rapid growth rate is due to the species exploiting signal crayfish.

Dace have more recently become established in Loch Ken and the population may not yet have stabilised within the overall ecology of the system. Growth rates in 2019 were below average comparable to English data and this finding is consistent with 2017.

4.3 Conclusions

- Loch Ken continues to support a healthy fish population. This is despite the presence of a significant signal crayfish population and the negative publicity generated around this issue. It is recognised that the fishery has changed over time – for a number of reasons not just because of the presence of the crayfish. At times it is the limited access to the loch which restricts the use of the fishery rather than any other factor. Recent progress has been made by match organisers to increase access and angling opportunities on the loch.
- The fish populations within Loch Ken appears to be coping with the pressures that signal crayfish are exerting upon them e.g. predation of eggs, competition for food and grazing of aquatic weeds (which can be important fish spawning and nursery areas for young fish). There is no indication, based on the limited data collected and collated, that any component of the fish community is unhealthy or under identifiable stress.
- The monitoring and sampling confirmed that the main species targeted by anglers are bream, roach, pike, perch and to a lesser extent dace and ruffe. The bream population makes up a significant portion of the overall catch of match anglers. While the bags of bream caught are highly rated by anglers during good fishing conditions the maximum sizes of bream are not particularly notable. Growth rates of bream in Loch Ken are below the average found in data collected from England but are still healthy. Loch Ken is highly rated as a perch fishery with large specimen perch reported. On-going monitoring is being undertaken to assess and understand the perch and pike fish community of Loch Ken as well as species sampled within the match.

5. RECOMMENDATIONS

5.1 Monitoring of Loch Ken fish populations

It is advised that a programme of surveys to monitor the fisheries resource within Loch Ken is undertaken over a further four year period based on the techniques used in this study. These surveys would provide information on the health of the overall fish population and help to understand annual fluctuations in fish recruitment and growth rates. It is important to ensure that any increased angling pressure which may result from the overall project is undertaken in a sustainable manner.

It is recommended that the following surveys and activities are undertaken annually:

- Catches from two angling matches, in March and September, should be surveyed following the protocol (ANNEX 1).
- Continue to train and assist a small group of anglers who can sample pike and perch from boats throughout the year. Encourage new anglers to get involved in this sampling effort and report findings during each reporting phase.

6. REFERENCES

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7. ANNEX 1: ANGLING MATCH STRATEGY

GFT have recognised that Loch Ken Coarse fish matches can provide a brilliant resource for sampling the coarse fish community within Loch Ken.

With a number of anglers fishing the loch at one time (40+), adopting very similar fishing methods, and for the same fishing duration - sampling fish on a match day will help GFT both identify the fish species most readily available to anglers fishing from the bankside and generate baseline data for future year's comparison on species length, weight and age class structures.

Developing an approach to fish sampling

GFT attended a match in December 2016 where many fish were captured by anglers. A total of 302 fish were length sampled (172 bream, 55 roach, 45 ruffe, 15 dace and 15 perch and a wide range of fish lengths recorded (172 – 400 mm bream, 93 – 200 mm roach, 92 – 160 mm perch, 110 – 210 mm dace and 68 – 105 mm ruffe). At this event it was clear that it was not likely to be possible to sample all fish from future matches given the time, staff and logistical constraints in doing so. Therefore, an approach to sampling has been prepared to ensure that representative samples of the range of fish captured are recorded to make best use of the staff resources available and the opportunity to gather valuable data.

We have investigated how age could be extrapolated from recorded fish length data using the EA document 'Fish Ageing Survey Report (2014)'. Using scale samples, the report confirmed that fish age structures in bream, roach and perch can be verified in relation to age classes predicted by length data.

Using the average length to age conversion table provided within the report, lengths of bream, roach and perch have been categorised into age classes by compartmentalising groups of lengths within a recording sheet (Appendix 1). Predicted age classes are shown as alternate shaded and clear bands in the length categories and these will be used to help guide scale sampling within these bands to verify predicted age class structures of bream, roach and perch caught at Loch Ken matches.

Weight information will also be collected from across the predicted age class bands to allow an assessment of condition factor to be determined by species and age.

It is proposed that the following general approach to sampling will be undertaken:

- All fish of all species will have individual lengths recorded.
- For all species other than ruffe i.e. bream, perch, roach and dace, weights will be recorded and scale samples taken from every 10th fish not within the predicted 0+ age class.
- A subset of these scale samples will be selected for reading and analysis with other samples archived for later use.

It is noted that volume of fish captured in the match may prevent all fish being measured for length or limit the feasibility of collecting scales and weights from every tenth fish. In such circumstances GFT will determine how best to proceed to maximise the data collected at any match.

General methods

GFT will aim to sample between 200 and 300 fish during each Loch Ken match in cooperation with the anglers and match organisers. GFT will be present at the close of the match and follow the competition weigh-in and transfer anglers catches held in keep nets after weigh-in

into GFT keep nets. Fish held in GFT keep nets will be secured in the water on each section of the competition until weigh-in has finished and processing can commence.

Fish will be processed from as wide a geographic range as the match competition is spaced (normally west bank within NGAA section and east bank on Glenlaggan). GFT will split into two teams to cover the east and west bank.

Working in pairs, GFT will sample all (or most) fish for length data; weight and scale samples (not for ruffe) will be collected from every tenth fish of each species across a range of sizes.