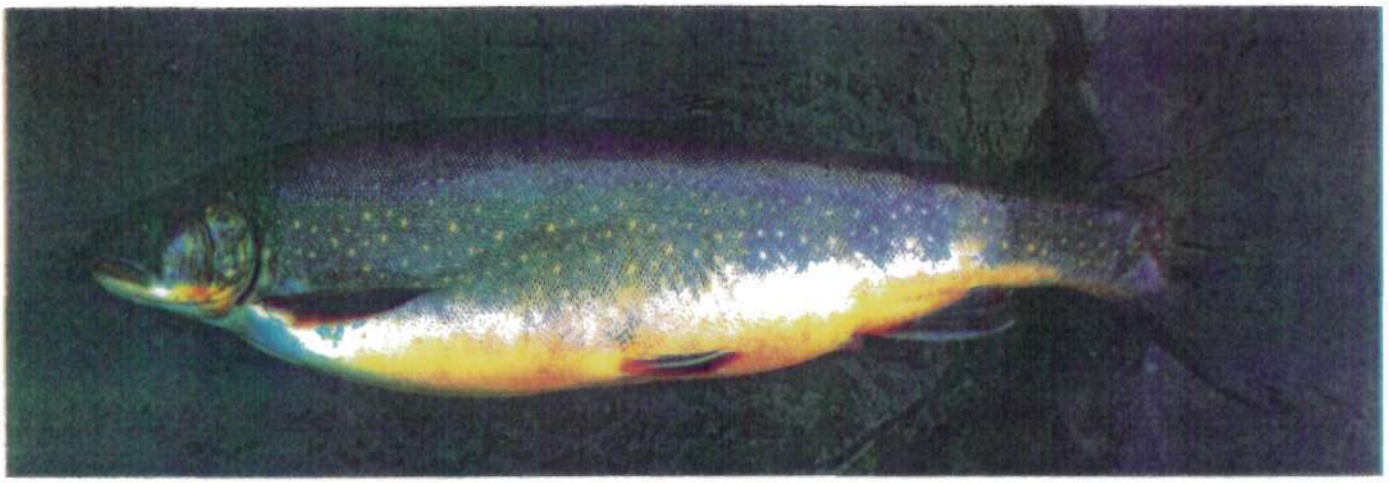
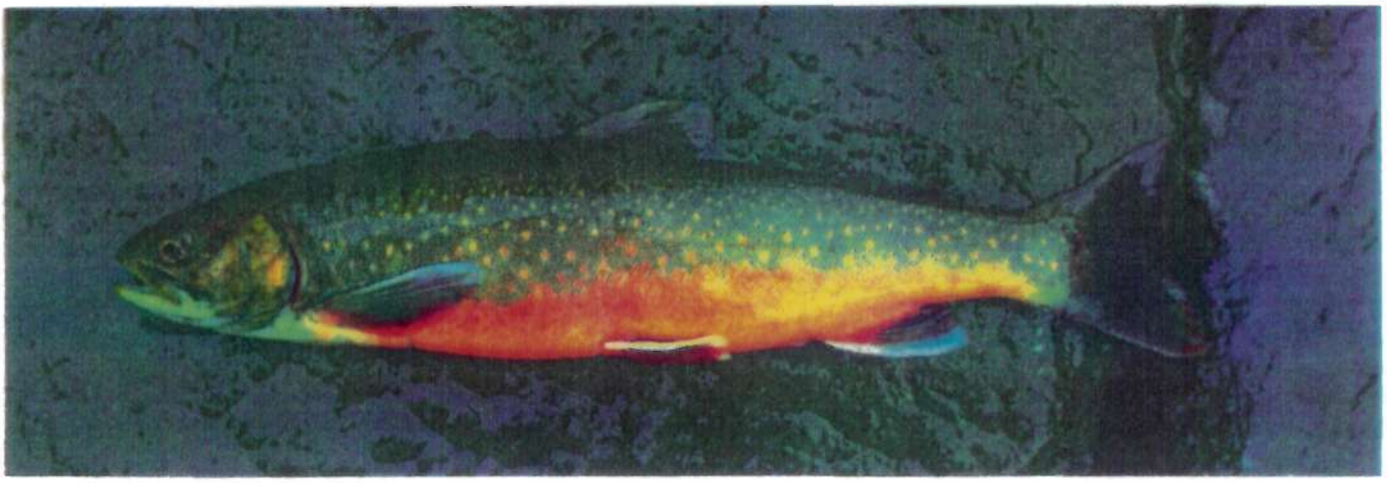
Ennerdale Water: A Pilot Study





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Arctic Charr From Ennerdale Water: A Pilot Study

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Summary

(1) Samples of Arctic charr were obtained from Smithy beck and the River Liza during the spawning period using fyke nets. Smithy Beck was sampled on three occasions (18 - 20/11/91) and the Liza once (20/11/91). These streams are the only known spawning sites of charr from Ennerdale Water.

(2) A total of 161 fish (95 males and 66 females) was caught and tagged using 'visual implant tags'; 141 from Smithy Beck and 20 from the Liza.

(3) The sex ratio of the sample of the spawning stock was found to differ between the two streams. Chi squared analysis revealed a significant difference from a 1 : 1 sex ratio with the exception of the sample obtained on the 18/11/91. Males were more abundant than females in Smithy Beck (overall ratio 1.9 : 1.0) and vice versa in the Liza (1.0 : 2.5).

(4) Although age determination was not carried out it was inferred from the data of Partington and Mills (1988) that the majority of fish involved in the spawning migration were aged between 5 and 8 years.

(5) The number of fish caught was lower than that expected during the spawning period in relation to observations made in the past (D. Pearson pers. comm.). In addition, a large number of fish (males and females) were found to make successive spawning runs over the study period.

(6) The results of this pilot study indicate that further research is required in order to fully assess the status of the charr population as a whole.

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Arctic Charr From Ennerdale Water: A Pilot Study

1. Introduction

One of the key objectives stated in the NRA Corporate Plan with respect to fisheries is the assessment of the status of fish stocks and to formulate policies to maintain, improve and develop them. The NRA is also responsible for the conservation of flora and fauna dependent on the aquatic environment (Water Resources Act, 1991). This can only be achieved if adequate information on the biology and ecology of the species present is available.

There are three species in the North West, Arctic charr (Salvelinus alpinus, L.), schelly (Coregonus lavaretus, L.), and vendace (C. albula, L.), which Maitland and Lyle (1991) have reported as rare and vulnerable and have been identified as requiring the preparation and implementation of a conservation management plan. The coregonids are currently being studied by the Institute of Freshwater Ecology (project number D01(90)2 249).

The Arctic charr of the British Isles are relicts of the Ice Age. During that period of time the lakes they inhabited were isolated from the sea and the anadromous characteristics of the fish were lost such that after the retreat of the ice cap the species remained isolated. Thus the population of each lake has developed a certain degree of stock individuality, and thus has its own intrinsic value.

The presence of Arctic charr in Ennerdale Water has resulted in it being designated as a Site of Special Scientific Interest (L. Oliver pers. comm.). These fish and one race of the species in Lake Windermere are the only English populations of charr known to spawn in running water (Partington and Mills, 1988).

Associated with Ennerdale charr is the copepod parasite Salmincola edwardsii which has not been recorded from any other charr inhabited waters of the Lake District. However, it has been recorded on charr from four Scottish Lochs (Stack, Lee, Tay and Doon). The unique nature of Ennerdale is further highlighted by the presence of two crustaceans, Mysis relicta and Limnocalanus macrurus. The former has been recorded in Ireland while the latter is not known to exist anywhere else in the British Isles (Fryer, 1981).

The aim of this pilot study was to obtain baseline data on charr that spawn in Smithy Beck and the River Liza. This would indicate the current status of the population and help identify areas requiring further investigation.

Ennerdale charr are known to ascend two tributaries which drain into Ennerdale Water (the River Liza and Smithy Beck), over a 10-14 day period to spawn. This occurs during November and takes place at night. The fish are believed to return to the lake during the day.

2. Description of the study area

Ennerdale Water is situated in West Cumbria at an altitude of 112m, with a surface area of 300ha and a maximum depth of 42m (Maitland and Lyle, 1991) (Fig. 1).

This study focussed on the River Liza and Smithy Beck which are the only known spawning sites of Arctic charr from Ennerdale Water. The River Liza is the main feeder stream which rises from an altitude of 550m (N.G.R. NY 212107) and runs for approximately 10km before entering Ennerdale Water. Smithy Beck (N.G.R. NY 132162) rises on Gale Fell at an altitude of 450m and flows for a distance of 2.5km before discharging into the lake. For most of their lengths the Liza and Smithy Beck flow through coniferous woodland which also extends to border on the north west and south west shore of Ennerdale.

In Smithy Beck the spawning ground is limited to a stretch approximately 300m upstream of the lake due to the presence of an impassable waterfall. In the River Liza most of the spawning occurs over a 1.3km section upstream of the lake to the 'Irish Bridge'. Very few charr have been seen above the 'Irish Bridge' during the spawning period.

The River Ehen flows out of Ennerdale, travelling a distance of approximately 25km before entering the Irish Sea.

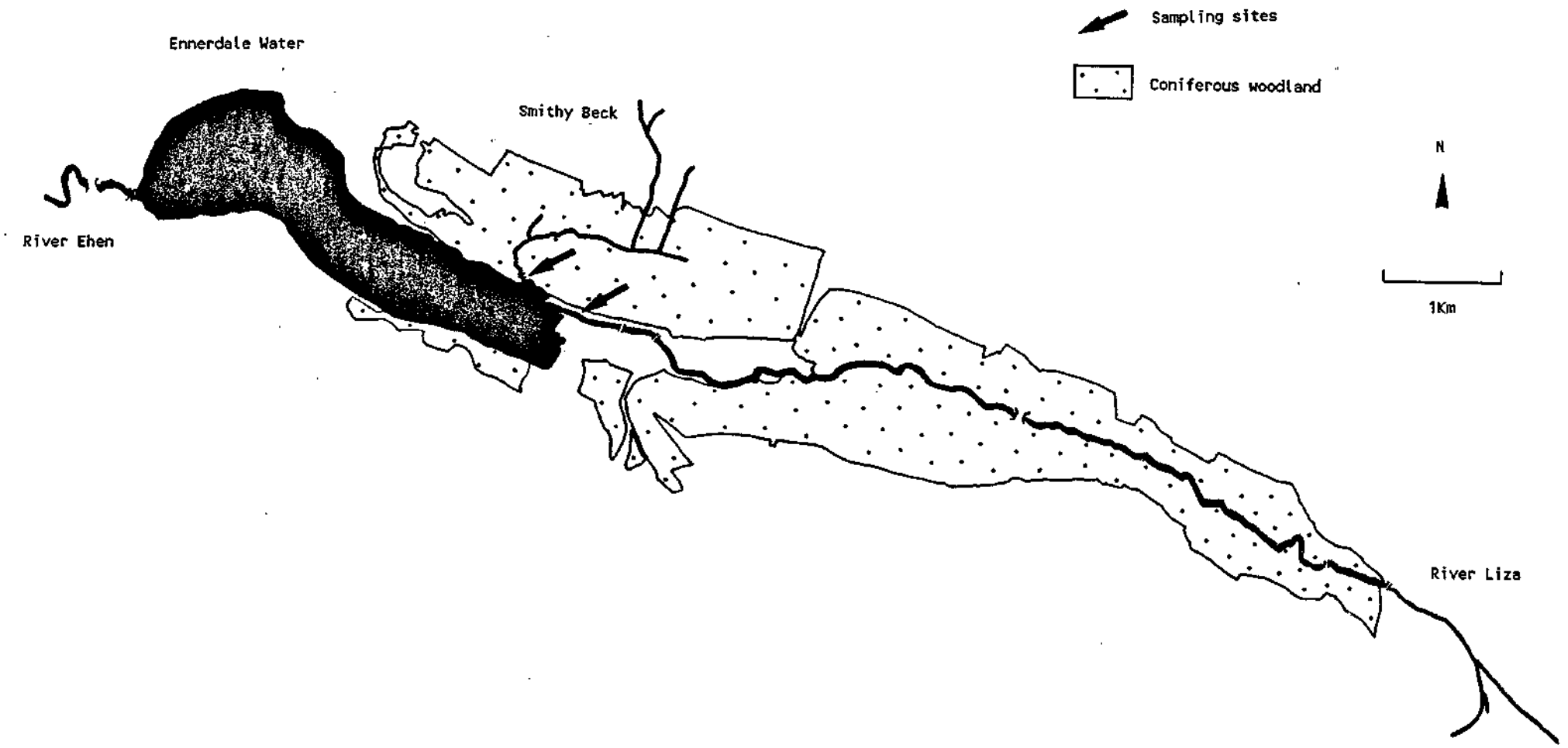
The Liza and Smithy catchment as well as a considerable proportion of the land surrounding Ennerdale Water consists of igneous rocks (tuffs and granite) which account for the oligotrophic nature of the lake. The rest of the area is of Ordivician sedimentary rock and some drift material.

3. Methods

Sampling was carried out at night on three successive occasions during the spawning period; 18, 19 and 20/11/91. Smithy Beck was sampled on all three nights and the Liza once (20/11/91).

On each evening during the sampling period a visual inspection of both streams was conducted to assess the size of the spawning run and to determine the time to set the fyke nets. After allowing the fish to ascend the stream up to three fyke nets were set in parallel across the stream. The fyke nets were re-examined within 3 hours

Fig. 1 The Sampling Sites at Ennerdale Water



and the sample collected. The nets were set a maximum of 3 times in one night. On Smithy Beck and the River Liza the fyke nets were situated approximately 10m and 300m upstream of the Lake, respectively.

In Smithy Beck (which was very shallow, 15-45cm) the charr were encouraged using torches to swim downstream into the fyke nets. This 'herding' technique was used on all three sampling occasions. In the Liza a passive approach was used where the fish were allowed to swim into the fyke nets on their return journey to the lake.

All the fish collected were anaesthetised (using phenoxyethanol), sexed and their fork length measured to the nearest 0.5cm below. An attempt was made to collect scale samples for age determination however they proved too difficult to remove. Each fish was marked with a visual implant tag (carrying an identification number) which was inserted in the clear tissue behind the eye. The adipose fin of tagged fish was removed.

4. Results

A total of 161 fish (95 males and 66 females) was caught and tagged over the 3 day period, 141 from Smithy Beck and 20 from the Liza. The sex ratios are shown in Table 1, and the catch and recapture data in Tables 2 and 3 respectively, and in Fig. 2. The raw data is presented in Appendices 1 and 2. Length frequency histograms for the fish from Smithy Beck and the Liza are shown in Figs. 3 and 4 respectively.

Catch rates were not calculated because the nature of the study was investigatory and as such the methodology was allowed to vary.

4.1 Smithy Beck

In Smithy Beck 85 fish were caught and tagged on the first night of sampling (18/11/91). Of these 51 were male and 34 female, a sex ratio of 1.5 : 1.0 (Tables 1 and 2).

On the 19/11/91 36 fish were caught with a sex ratio of 3.0 males : 1.0 female, however 47% of these fish were recaptures from the previous night. The recaptured fish consisted of 41% males and 67% females.

A total of 64 fish was caught on 20/11/91 with a sex ratio of 1.9 males : 1.0 female. Of these fish 42% were recaptures. The proportion of males and females recaptured were 48% and 32% respectively. Six of the fish tagged on 18/11/91 were recaptured on 19/11/91 and again on 20/11/91; 5 males and 1 female (Fig. 2).

TABLE 1. SEX RATIO OF SPAWNING STOCK (1991)

DATE	SITE	MALES	:	FEMALES	CHI SQUARED VALUE	SIGNIFICANT DIFFERENCE (5% LEVEL)
18/11/91	SMITHY	1.5	:	1.0	3.40	NO
19/11/91	SMITHY	3.0	:	1.0	9.00	YES
20/11/91	SMITHY	1.9	:	1.0	6.25	YES
20/11/91	LIZA	1.0	:	2.5	3.86	YES (DEGREES OF FREEDOM = 1)
OVERALL RATIOS	SMITHY	1.9	:	1.0		
	LIZA	1.0	:	2.5		

TABLE 2. CATCH STATISTICS (The percentage composition of recaptured fish is shown in parenthesis)

DATE	SITE	SAMPLE No.	MALES n	FEMALES n	TOTAL
18/11/91	SMITHY	1	29	13	42
		2	17	13	30
		3	5	8	13
TOTAL			51	34	85
19/11/91	SMITHY	1	8 (50)	5 (40)	13 (46)
		2	11 (27)	1 (100)	12 (33)
		3	8 (50)	3 (100)	11 (64)
TOTAL			27 (41)	9 (67)	36 (47)
20/11/91	SMITHY	1	22 (50)	11 (27)	33 (42)
		2	20 (45)	11 (36)	31 (42)
TOTAL			42 (48)	22 (32)	64 (42)
20/11/91	LIZA	1	6	15 (1)*	21
TOTAL			126	80	206

TABLE 3. FISH RECAPTURES

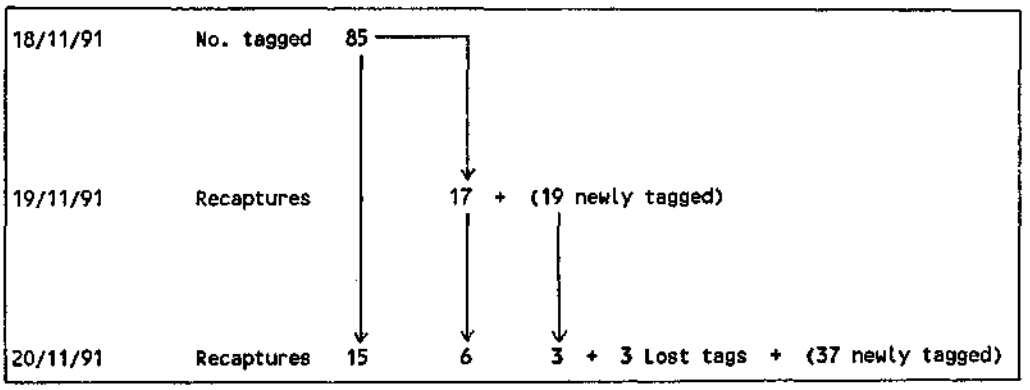
	MALES			FEMALES			TOTAL
DATE	Tot Cat	Recap 1	Recap 2	Tot Cat	Recap 1	Recap 2	
18/11/91 (S)	51	0	0	34	0	0	85
19/11/91 (S)	27	11	0	9	6	0	36 (47)
20/11/91 (S)	42 $	14	3	22	7	0	64 (42)
20/11/91 (L)	6	0	0	15	1*	0	21
Total	126	25	3	80	14	0	206

$ = 3 male fish lost their tags and were retagged

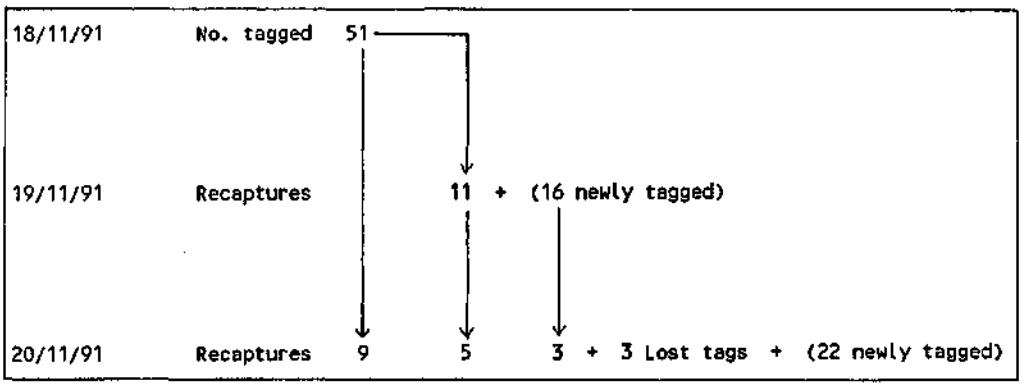
N.B. Tot Cat = Total Catch
Recap 1 = Recaptured fish first caught on 18/11/91
Recap 2 = Recaptured fish first caught on 19/11/91
* = Fish first caught and tagged in Smithy Beck
(S) = Smithy Beck
(L) = River Liza

Fig. 2 Flow diagrams indicating number of recaptured fish in Smithy Beck

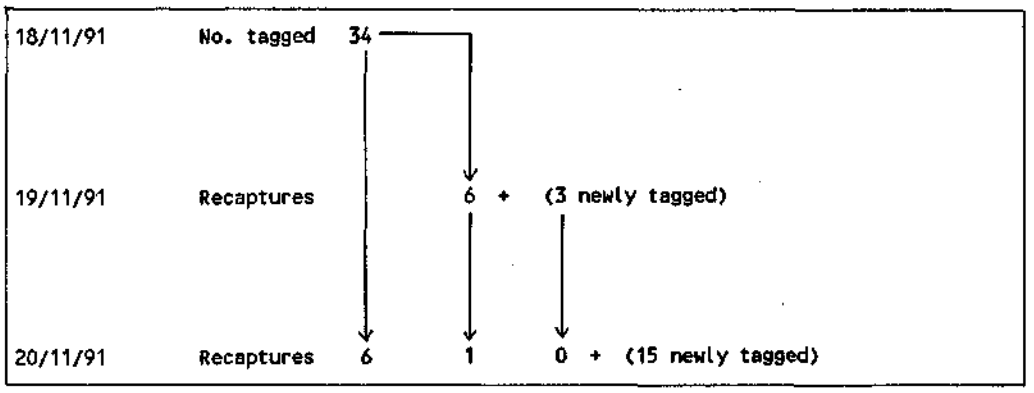
(a) Males and females combined



(b) Males



(c) Females



4.2 River Liza

On the 20/11/91 21 fish were caught in the Liza (one of these was a tagged fish first caught in Smithy Beck on the 18/11/91). In contrast to Smithy Beck females were more abundant than males (1.0 male : 2.5 females).

4.3 Length frequency distribution

It was not possible to determine age classes from the length frequency distribution pattern (Figs. 3 and 4). However, some indication of the age of these fish is provided by reference to the work of Partington and Mills (1988). They give mean length at age for a sample of Ennerdale charr (Appendix 3). From this it can be inferred that the majority of spawning fish in the sample taken during the 1991 survey were between 5 and 8 years old (27-32cm).

There was some evidence in the data obtained from Smithy Beck to suggest that males mature before females (Fig. 3), however, a larger sample size is necessary to test whether this is significant.

4.4 Tag retention

During the course of the study 161 fish were tagged and of these 38 were recaptured. Of the 38 fish recaptured 92% had retained their tag, those which had lost their tag were retagged (Appendix 1).

5. Discussion

The size composition of the spawning stock was similar to that obtained by Partington and Mills (1988) with the majority of fish being between 27-32cm; between 5 and 8 years old. However, smaller fish were not recorded in their study, but they were evident in the 1991 survey, the smallest of which was 22cm in length.

With the exception of the first night of sampling at Smithy Beck (18/11/91) the sex ratio of the fish from both streams differed significantly from a 1 : 1 ratio at a 5% level of significance (Table 1). The male : female ratio of the fish from Smithy Beck was found to be 1.9 : 1.0. The reverse was found at the Liza where the male : female ratio was 1.0 : 2.5. If females are first to leave the spawning ground this may explain their greater numbers in the Liza sample. The results from the two streams are not comparable because of the differences in the sampling technique.

An interesting feature of the results is the number of repeat spawners recorded in Smithy Beck during the study. On the 19/11/91 the sex ratio of the repeat spawners was 1.8 males : 1.0 females and on the 20/11/91 the ratio was 2.9 males : 1.0 females. It is not clear whether the

Fig. 3 Length Frequency Distribution Of Charr Smithy Beck (1991)

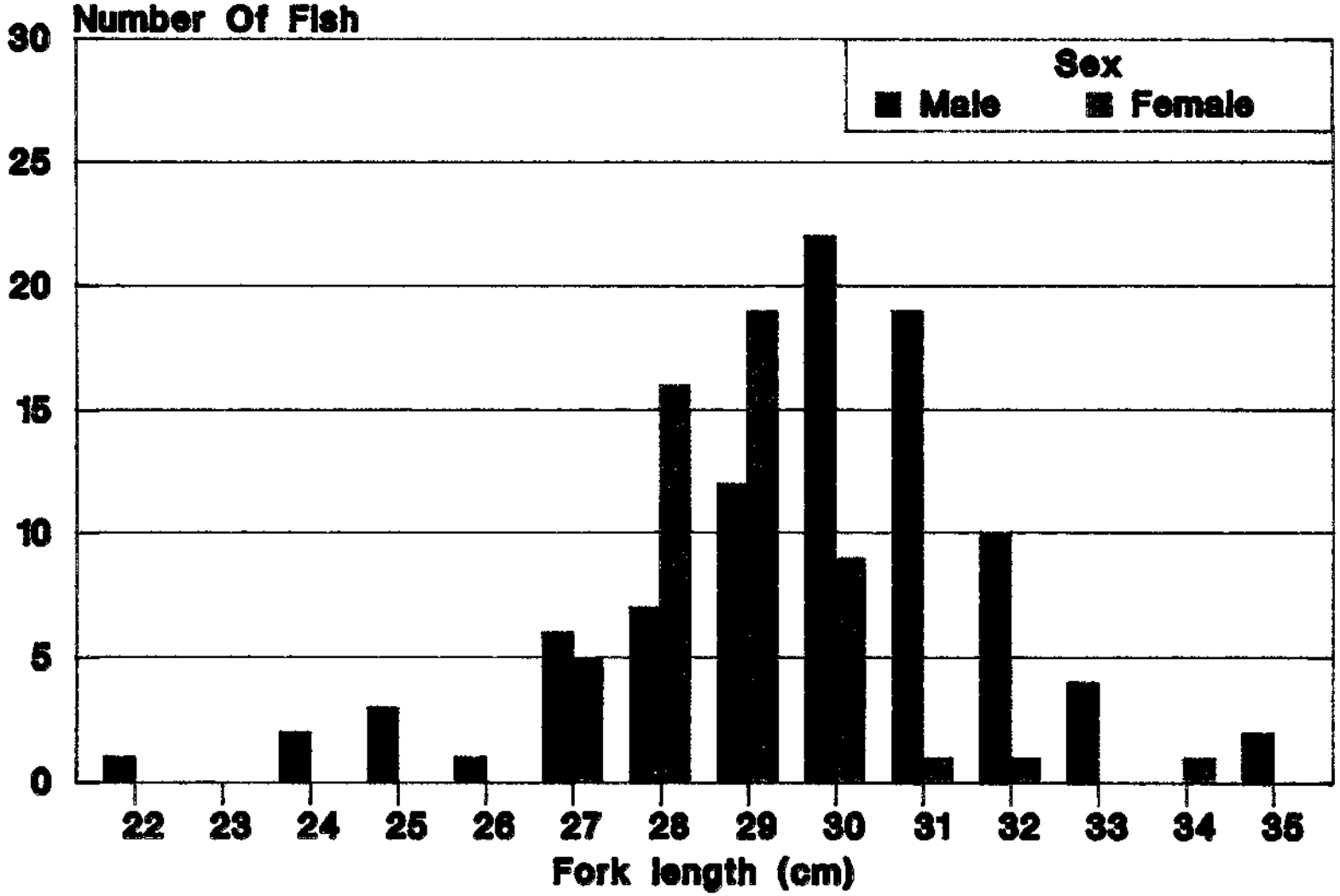
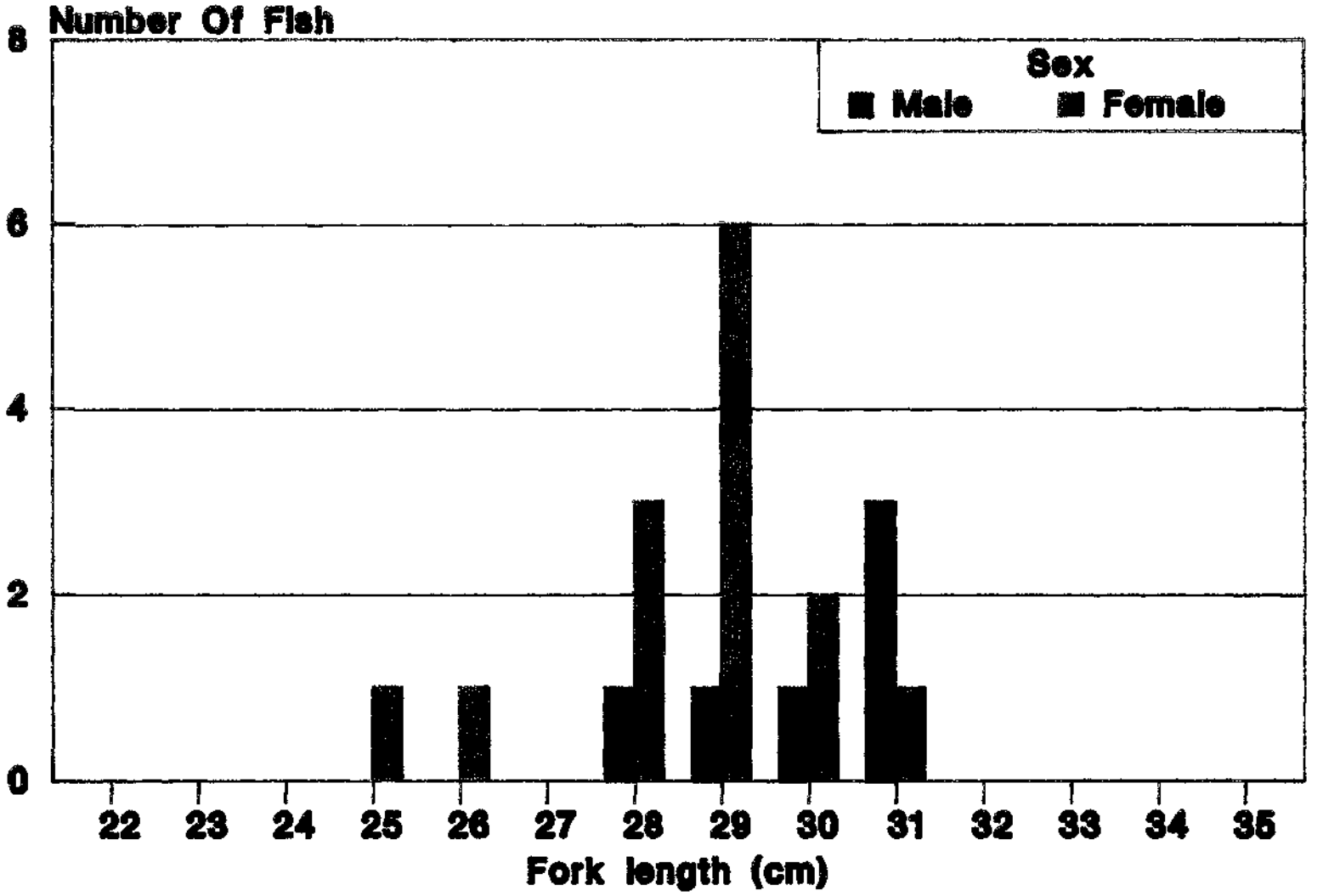


Fig. 4 Length Frequency Distribution Of Charr The River Liza (1991)



presence of repeat spawners is their natural pattern of behaviour or was a consequence of the sampling technique which may have inhibited fish from spawning at their first attempt.

The number of fish involved in the spawning migration during the study period was considerably less than that expected from observations of the spawning period in previous years. This was most striking in the River Liza (D. Pearson pers. comm.) where so few fish were seen to ascend the river on the 18 and 19/11/91 that it was decided to concentrate sampling effort on Smithy Beck for those two occasions.

As information on the ecology of charr in Ennerdale Water is extremely limited it is not possible to say whether the low numbers recorded in the Liza and Smithy Beck during this study are representative of the status of the spawning population.

It is possible that spawning occurs along the shore of Ennerdale Water as well as in the two afferent streams investigated, as is the case in Windermere (Frost, 1965), but there is no data to verify this. Even if this is the case these results could still imply that a component of the spawning stock may be under stress.

It should be noted that for a number of days prior to the sampling period high flows were observed in the River Liza and Smithy Beck. It may be the case that most of the spawning activity took place at that time and what was recorded during the study was the final few days of the spawning period.

Acidification is one of the main threats to Arctic charr populations. The elimination of charr from the Scottish Lochs Granoch and Dungeon has been attributed to this phenomenon (Maitland et al., 1991). In the River Liza biological surveys conducted in 1978, 1980, 1982, and 1985 showed that the invertebrate fauna was typical of acidified oligotrophic conditions (Prigg, 1986). Subsequent surveys (1987-1991) suggest similar conditions prevail with an absence or low relative abundance of the indicator species Baetis rhodani.

Stream acidity can be enhanced due to the presence of coniferous woodland by the concentration of atmospheric acid deposition (Hornung et al., 1989; Weatherley et al., 1989) and this may be a factor in the Liza catchment.

6. Conclusion

The results of this pilot study demonstrate that a more detailed investigation is necessary to determine the status of charr in Ennerdale Water and to obtain basic biological information.

The comparatively low numbers of charr caught during the survey may be of some concern, however, it is quite possible that the peak of the migratory period was missed and these results are merely a reflection of this.

Further research is necessary to ensure the survival of this unique population. Partington and Mills's (1988) study showed that of the eight Cumbrian lakes studied, the charr in Ennerdale stood out on morphological, meristic and genetic characters, having a rapid growth rate compared with other populations of charr despite the oligotrophic environment.

7. Recommendations

(1) To obtain basic biological information such as age, growth, diet, fecundity, age at first spawning, and number of spawnings.

(2) To determine whether water quality over the period from spawning to emergence is effecting egg to alevin survival in the Liza and Smithy Beck.

This would involve continuous water quality monitoring, particularly pH associated with egg box trials.

(3) A follow up survey should rely on a 'passive' fyke netting strategy similar to that employed in the River Liza. The fyke nets could be arranged so that upstream and downstream migrants are sampled. This would also give an accurate estimate of the period of residency in the stream.

(4) To continue with the tagging programme in conjunction with panjetting for fish in both streams so that lost tags do not result in a loss of information on matters such as stream specificity of the spawning population.

Such work would also give an indication of mortality rates if carried out over more than one year.

(5) To investigate the fate of charr fry from emergence to emigration into the lake. This may be achieved by the use of fine meshed nets to obtain samples of the juveniles.

It may be useful to investigate areas of the lake around the Liza and Smithy Beck at emigration to see if the juveniles are subjected to predation e.g. by brown trout.

(6) To make an assessment of the population size (spawning and non-spawning stock) and its distribution in the lake before and during the spawning period by the use of hydroacoustics. This work has already been initiated by the Northern Area Fisheries Staff (Douglas, S.R. in prep.).

(7) To determine whether the charr observed in the River Liza and Smithy Beck are distinct spawning populations.

(8) To make an approach to IFE regarding the availability of any unpublished data on Ennerdale charr.

8. Acknowledgements

We gratefully acknowledge the help and cooperation received from Dave Pearson, Steve Whittam, David Smith, Jim Muir, George Fisher, and Mike Bell in the collection of the data.

Particular thanks are due to Dave Pearson who was heavily involved in the setting up and running of this pilot study.

9. References

Frost, W.E. (1965). Breeding habits of Windermere charr, Salvelinus willughbii (Gunther), and their bearing on the speciation of these fish. Proc. Roy. Soc. B. 163, 232-284.

Fryer, G. (1981). The copepod Salmincola edwardsii as a parasite of Salvelinus alpinus in Britain, and a consideration of the so-called relict fauna of Ennerdale Water. J. Zool., Lond. 193, 253-268.

Hornung, M., Adamson, J.K, Reynolds, B. and Stevens, P.A. (1989). Impacts of forest management practices in plantation forests. In 'Effects of land use in catchments on the acidity and ecology of natural surface waters'. Air pollution research report 13. Barth H. (ed.). Commission of the European Communities, Brussels.

Maitland, P.S., May, L., Jones, D.H. and Doughty, C.R. (1991). Ecology and conservation of Arctic charr, Salvelinus alpinus (L.), in Loch Doon, An acidifying Loch in Southwest Scotland. Biol. Cons. 55, 167-197.

Maitland, P.S. and Lyle, A.A. (1991). Conservation of freshwater fish in the British Isles: the current status and biology of threatened species. Aquat. Cons.: Mar. Freshwat. Ecosys. 1, 25-55.

Partington, J.D. and Mills, C.A. (1988). An electrophoretic and biometric study of Arctic charr, Salvelinus alpinus (L.), from ten British lakes. J. Fish Biol. 33, 791-814.

Prigg, R. (1986). Preliminary note on the present fish population and potential of Ennerdale Water tributaries, with special reference to salmon. NRA internal report NC306(2/86).

Water Resources Act (1991). HMSO, London.

Weatherley, N.S., Brown, A.F., McCahon, C.P., Pascoe, D., Poulton, D., Thomas, S.P., and Ormerod, S.J. (1989). The biological effects of an acid episode in a forest stream. In 'Effects of land use in catchments on the acidity and ecology of natural surface waters'. Air pollution research report 13. Barth, H. (ed.). Commission of the European Communities, Brussels.

Appendix 1

Sex, length and tag number of charr recorded in Smithy Beck (1991)

Date	Sex	Length (cm)	Tag number	Sex	Length (cm)	Tag Number
18/11/91	Male	30.5	K00	Male	28.5	K52
	Male	24.5	K01	Female	28.5	K53
	Male	30.5	K02	Female	27.0	K54
	Male	31.0	K03	Female	28.5	K55
	Male	34.5	K04	Female	27.5	K56
	Female	29.0	K05	Male	30.0	K57
	Male	28.5	K06	Male	24.0	K58
	Female	28.0	K07	Male	27.5	K59
	Female	29.5	K08	Female	28.0	K60
	Female	29.5	K09	Female	29.0	K61
	Female	29.0	K10	Male	28.5	K62
	Female	29.0	K11	Female	34.0	K63
	Male	31.0	K12	Male	29.0	K64
	Male	27.0	K13	Male	28.5	K65
	Male	29.5	K14	Male	27.5	K66
	Female	29.5	K15	Female	27.5	K67
	Male	34.5	K16	Female	27.5	K68
	Male	27.5	K17	Male	25.0	K69
	Male	31.5	K18	Female	28.0	K70
	Male	30.5	K19	Male	31.5	K71
	Female	30.0	K20	Male	21.5	K72
	Male	29.5	K21	Female	28.5	K73
	Male	29.5	K22	Female	28.0	K74
	Male	31.5	K23	Male	30.0	K75
	Female	28.0	K24	Male	31.0	K76
	Male	29.5	K25	Female	28.5	K77
	Female	28.5	K26	Female	26.5	K78
	Male	31.0	K27	Male	29.5	K79
	Male	30.0	K28	Male	30.5	K80
	Female	28.5	K29	Female	27.0	K81
	Male	27.5	K30	Female	30.0	K82
	Male	29.5	K31	Female	30.5	K83
	Male	30.0	K32	Female	28.5	K84
	Male	24.0	K33			
	Female	29.5	K34			
	Female	30.0	K35			
	Male	28.5	K36			
	Male	30.0	K37			
	Male	29.5	K38			
	Male	31.5	K39			
	Male	27.0	K40			
	Male	28.5	K41			
	Male	28.5	K42			
	Male	30.5	K43			
	Female	28.0	K44			
	Female	26.5	K45			
	Male	30.5	K46			
	Male	29.5	K47			
	Male	29.5	K48			
	Male	30.5	K49			
	Male	30.5	K50			
	Female	28.5	K51			

Appendix 1 (Cont.)

Date	Sex	Length (cm)	Tag number	
19/11/91	Male	33.0	K85	
	Female	29.0	K86	
	Male	27.0	K87	
	Male	30.0	K88	
	Male	31.0	K89	
	Female	29.5	K90	
	Female	28.0	K91	
	Male	30.0	K92	
	Male	28.0	K93	
	Male	32.0	K94	
	Male	32.0	K95	
	Male	30.5	K96	
	Male	28.5	K97	
	Male	28.0	K98	
	Male	30.0	K99	
	Male	32.0	KF0	
	Male	31.5	KF1	
	Male	29.5	KF2	
	Male	25.0	KF3	
	Male	34.5	K04	*
	Female	28.0	K07	*
	Female	29.0	K11	*
	Male	27.0	K13	*
	Male	34.5	K16	*
	Male	31.5	K18	*
	Female	28.0	K24	*
	Male	29.5	K25	*
	Male	28.5	K41	*
	Male	30.5	K49	*
	Male	28.5	K52	*
	Female	28.5	K55	*
	Female	27.5	K56	*
	Male	28.5	K62	*
	Male	28.5	K65	*
	Female	27.5	K68	*
	Male	31.0	K76	*

Appendix 1 (Cont.)

Date	Sex	Length (cm)	Tag number	Sex	Length (cm)	Tag number
20/11/91	Male	30.5	KF5	Male	26.0	KJ8
	Male	32.0	KF6	Male	27.0	KJ9
	Female	28.0	KF7	Male	31.0	KK1
	Male	32.5	KF8	Female	29.5	KK2
	Female	27.5	KF9	Male	30.5	KK3
	Male	30.0	KH0	Female	27.5	KK4
	Female	29.0	KH1	Male	31.0	KK5
	Male	31.0	KH2	Male	29.0	KK7
	Female	29.0	KH3	Female	28.0	KK8
	Male	30.0	KH4	Female	29.0	KK9
	Female	28.5	KH5	Male	26.5	KL0
	Male	32.5	KH6	Male	27.5	KL1
	Male	28.5	KH7	Male	27.0	KL2
	Male	26.5	KH8	Male	29.5	KL3
	Female	32.0	KH9	Male	30.0	* Retagged as KK0
	Female	27.5	KJ0	Male	31.0	* Retagged as KK6
	Male	33.0	KJ1	Male	30.5	K02 *
	Male	29.5	KJ2	Male	27.0	K13 **
	Female	29.0	KJ3	Female	28.0	K24 **
	Male	34.0	* Retagged as KF4	Male	30.0	K32 *
	Female	29.5	K08 *	Female	30.0	K35 *
	Male	31.0	K12 *	Male	30.5	K43 *
	Male	29.5	K14 *	Female	26.5	K45 *
	Male	31.5	K18 **	Male	29.5	K48 *
	Female	28.5	K29 *	Male	28.5	K52 **
	Male	28.5	K42 *	Female	28.5	K53 *
	Male	27.5	K59 *	Male	30.0	K92 *
	Male	28.5	K62 **			
	Male	28.5	K65 **			
	Female	27.5	K67 *			
	Male	29.5	K79 *			
	Male	27.0	K87 *			
	Male	31.0	K89 *			
	Female	28.0	KJ4			
	Female	27.5	KJ5			
	Male	31.5	KJ6			
	Female	28.5	KJ7			

* Recaptured fish

** Recaptured twice

Appendix 2

Sex, length and tag number of charr recorded in the River Liza (1991)

Date	Sex	Length (cm)	Tag number	
20/11/91	Female	28.0	KL4	
	Female	30.0	KL5	
	Female	25.0	KL6	
	Male	28.5	KL7	
	Male	30.0	KL8	
	Female	26.0	KL9	
	Female	30.0	KA0	
	Male	31.5	KA1	
	Female	29.0	KA2	
	Male	31.5	KA3	
	Female	28.5	KA4	
	Male	29.5	KA5	
	Female	29.5	KA6	
	Female	29.0	KA7	
	Female	31.0	KA8	
	Male	31.5	KA9	
	Female	28.0	KB0	
	Female	29.0	KB1	
	Female	29.0	KB2	
	Female	29.0	KB3	
	Female	26.5	K78	*

* Recaptured fish first observed in Smithy Beck

Appendix 3 Length at age data for charr (Partington and Mills, 1988)

TABLE I. Mean lengths (mm) and numbers (in parentheses) of aged charr from eleven Lake District and one Welsh populations

Population	Age (years)										
	2	3	4	5	6	7	8	9	10	11	12
Buttermere	139(1)	221(2)	242(5)	271(5)	300(9)	301(6)	304(3)		326(2)		
Coniston Water		151(1)	207(4)	254(12)	272(19)	288(17)	296(18)	299(3)	299(2)	329(1)	
Crummock Water		116(4)	160(8)	187(19)	227(4)	251(8)	261(1)	260(1)			
Llyn Cwellyn	113(1)	164(3)	182(7)	200(7)	218(1)	219(3)			241(1)		
Ennerdale				270(2)	288(20)	304(41)	317(19)	339(3)	392(1)		
Haweswater	138(1)	155(1)	217(7)	236(19)	251(4)	270(4)	252(1)				
Thirlmere	122(4)	162(14)	182(6)	209(7)	225(6)	235(3)	234(4)	239(2)	238(2)		248(1)
Wastwater	117(16)	140(15)	171(4)	185(7)	187(1)						
WNBA*			234(3)	244(20)	264(14)	281(21)	288(13)	298(16)		303(1)	
WNBS*				251(6)	291(5)	305(10)	317(31)	332(30)	340(13)	346(6)	
WSBA*				288(10)	300(28)	319(10)	327(7)	335(8)	352(7)	347(2)	363(1)
WSBS*				291(2)	307(3)	329(5)	340(20)	347(17)	355(4)	354(3)	

*Windermere populations; see Materials and Methods section for abbreviations.